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SITE-SPECIFIC TECHNICAL REPORT FOR FREE PRODUCT RECOVERY TESTING AT SITE ~~S-4~~, Bldg. 348 KELLY AFB, TEXAS

DRAFT

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
(AFCEE/ERT)
8001 ARNOLD DRIVE
BROOKS AFB, TEXAS 78235-5357

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SITE-SPECIFIC TECHNICAL REPORT (A003)

for

FREE PRODUCT RECOVERY TESTING AT SITE S-4, KELLY AFB, TEXAS

by

A. Leeson, L. Cumming, C. Coonfare, and S. Serpa

for

Mr. Patrick Haas
U.S. Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
Brooks AFB, Texas 78235-5357

21 May 1997

Battelle
505 King Avenue
Columbus, Ohio 43201-2693

Contract No. F41624-94-C-8012

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EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Kelly Air Force Base (AFB) for a short-term field pilot test to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques used to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Kelly AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe, and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Kelly AFB is one of more than 40 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Kelly AFB were skimmer pumping and bioslurping.

Bioslurper pilot test activities were conducted at two monitoring wells: MW-11 and MW-9. Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pump tests were conducted. At monitoring well MW-11, pilot tests for skimmer pumping and bioslurping were conducted. The LNAPL

recovery testing was conducted in the following sequence: 40.9 hr in the skimmer configuration, 117.5 hr in the bioslurper configuration, and an additional 22 hr in the skimmer configuration.

At monitoring well MW-9, pilot tests for bioslurping were conducted. The LNAPL recovery testing was conducted for 23.9 hr in the bioslurper configuration.

Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

Baildown recovery tests were conducted at three monitoring wells: MW-8, MW-9, and MW-11. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and recovery potential. Overall the baildown recovery tests indicated a relatively rapid rate of LNAPL recovery into the wells. Short-term baildown recovery resulted in LNAPL thicknesses greater than or equal to the initial apparent thicknesses at monitoring wells MW-9 and MW-11. Based on these results, pilot testing was initiated on monitoring well MW-11, with a short-term bioslurper pump test also conducted at monitoring well MW-9.

Skimmer pump testing was conducted at monitoring well MW-11 in a continuous extraction mode for 40.9 hours. Small quantities of free-phase LNAPL were recovered during the two days of skimmer pump testing, indicating that gravity-driven recovery is minimal. Bioslurper testing was conducted for five days with significantly greater recoveries than during skimmer pumping. The recovery rate during the bioslurper pump test was 38 gallons/day during the first day and dropped to 26 gallons/day by day 3; however, the recovery rate increased to 39 gallons/day by day 5. Vacuum levels in the well were relatively low at 22″H_2O. The second skimmer pump test resulted in significantly greater LNAPL recoveries than observed during the first skimmer pump test, with an average LNAPL recovery rate of 21 gallons/day. These results indicate that the vacuum-enhanced bioslurper mode may have increased the LNAPL mobility, resulting in better recovery during skimmer pumping.

Groundwater production was relatively high during skimmer pumping and bioslurping, with a total of 27,000 gallons of groundwater produced. After the groundwater flowed though a filter tank and oil/water separator, the groundwater was pumped into an industrial waste line connected to the Base Industrial Wastewater Treatment Plant. Contaminant concentrations (3.5 mg TPH/L) were compatible with typical discharge guidelines.

In an effort to determine if the results at monitoring well MW-11 were representative of site conditions, bioslurper testing was conducted at monitoring well MW-9. Similar quantities of free-

phase LNAPL were recovered during this bioslurper pump test, with 49 gallons/day recovered. The wellhead vacuum on monitoring well MW-9 (5″H_2O) and groundwater production rate (5,300 gallons/day) were similar to those observed at monitoring well MW-11. Results at monitoring wells MW-11 and MW-9 appear to be representative of the site and indicate that vacuum-enhanced liquid recovery techniques are feasible.

Bioslurping also promotes mass removal in the form of in situ biodegradation via bioventing and soil-gas extraction. Vapor phase mass removal is the result of soil-gas extraction as well as volatilization that occurs during the movement of LNAPL free product through the extraction network. Given the measured vapor flowrate (76 scfm) and vapor concentrations, initial hydrocarbon removal rates were approximately 960 lb/day of TPH. Benzene concentrations were below detection limits. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication as to whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is sustained.

The internal combustion engine (ICE) used at the site was capable of reducing TPH emissions by 91%. After ICE treatment, the TPH emissions rate was reduced to approximately 86 lb/day. No benzene was detected in the emissions.

The initial soil-gas profiles at the site displayed high total volatile hydrocarbon vapor conditions across the 5.5- to 14-ft below ground surface horizons; however, oxygen concentrations were not significantly reduced except at one monitoring point (1% oxygen at MPB-13.5■). Oxygen concentrations at other monitoring points ranged from 10% to 20%. Soil-gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well MW-11 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were influenced at all monitoring points; however, oxygen concentrations dropped in all cases, so that by the end of the bioslurper pump tests, oxygen concentrations ranged from 1% to 8%. These results indicate that the initial concentrations measured at the monitoring points may have been high due to oxygen diffusion into the soils during monitoring point installation. Once bioslurping was initiated, oxygen-deficient soil gas was pulled past these monitoring points, creating the drop in oxygen concentrations. Based on the soil-gas permeability test, where pressure changes were detected up to 30 ft from the bioslurper well, it is likely that these areas will become fully aerated. In short, a five day extraction time frame at 76 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In situ biodegradation rates of 14 to 20 mg/kg-day were measured at three different locations. Based on a radius of influence of 28 ft and a hydrocarbon-impacted soil thickness of 16 ft, mass removal rates via biodegradation are on the order of 48 to 69 lbs of hydrocarbon per day. Thus, mass removal rates via biodegradation could be significant. These results indicate that bioventing is feasible at this site. Air injection bioventing is preferable over bioslurping and soil vapor extraction with respect to the elimination of hydrocarbon vapor emissions.

In summary, the on-site testing at Kelly AFB included the direct testing of gravity-driven and vacuum-driven LNAPL free product recovery techniques, bioventing, physical sampling, and tests relevant to soil vapor extraction. LNAPL recovery was most significant under vacuum-enhanced conditions; therefore, bioslurping is recommended at this site provided long-term treatment of groundwater is economically feasible. Vapor phase mass removal rates measured during bioslurper testing may be the result of soil gas removal (i.e., SVE) or volatilization during liquid entrainment. The generation of off-gas is undesirable and sustained rates of off-gas discharge cannot be estimated accurately from this test. The in situ respiration test and vadose zone radius of influence testing demonstrate that bioventing is feasible at this site.

DRAFT SITE-SPECIFIC TECHNICAL REPORT (A003)

for

FREE PRODUCT RECOVERY TESTING AT SITE S-4, KELLY AFB, TEXAS

21 May 1997

1.0 INTRODUCTION

This report describes activities performed and data collected during field tests at Kelly Air Force Base (AFB), Texas to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery technologies for removal of light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Kelly AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Kelly AFB is one of more than 40 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the Test Plan and Technical Protocol for Bioslurping (Battelle, 1995). Test provisions specific to activities at Kelly AFB are described in the Site-Specific Test Plan provided in Appendix A.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping

technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The two LNAPL recovery technologies tested at Kelly AFB were skimmer pumping and bioslurping. The specific test objectives, methods, and results for the Kelly AFB test program are discussed in the following sections.

1.2 Testing Approach

Bioslurper pilot test activities were conducted at two monitoring wells: MW-11 and MW-9. Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pump tests were conducted. At monitoring well MW-11, pilot tests for skimmer pumping and bioslurping were conducted. The LNAPL recovery testing was conducted in the following sequence: 40.9 hr in the skimmer configuration, 117.5 hr in the bioslurper configuration, and an additional 22 hr in the skimmer configuration.

At monitoring well MW-9, pilot tests for bioslurping were conducted. The LNAPL recovery testing was conducted for 23.9 hr in the bioslurper configuration.

Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

2.0 SITE DESCRIPTION

The information presented in the Site Description portion of this Test Plan was obtained from the document titled, Draft Technical Memorandum for the Quintana Road Project Site S-4 (Prepared for the U.S. Air Force Installation Program, Kelly Air Force Base, San Antonio, Texas. Submitted to the HAZWRAP Support Contractor Office, Oak Ridge, Tennessee. General Order Number 188-

97381C, Task Y-03, Volume I of II Text, by NUS, 1990). This document is referenced as NUS 1990 in this Test Plan text.

Site S-4 is located at the southeastern edge of Kelly AFB in Zone 3 and extends off base across Berman Road to the UPR yard and the Quintana Road residential area (Figure 1). Within Site S-4 are active (F/367) and abandoned (F/371) UST facilities and their associated subsurface pipelines. Facility F/371 was constructed in 1943 and contained 5 USTs. These tanks were used to store JP-4 jet fuel but were taken out of service in 1984 and eventually abandoned in 1986. Approximately 2,000 ft of underground piping was removed from operation in 1982 after pressure tests indicated that the system contained extensive leaks (NUS 1990).

Subsurface contamination at Site S-4 was documented during storm drain excavations along Quintana Road by the City of San Antonio in 1985 and 1988. A fuel-like substance was observed floating on exposed groundwater in trenches excavated to a depth of 30 ft below ground surface (bgs). The LNAPL was subsequently identified as JP-4 jet fuel, based on analyses conducted by the Texas Water Commission.

Following the detection of subsurface free product, Radian Corporation conducted site surveys under the Installation Restoration Program (IRP) and subsequent surveys were preformed by NUS Corporation under the Hazardous Waste Remedial Actions Program (HAZWRAP). During these activities, site geological characteristics, groundwater movement, and extent of subsurface contamination were investigated.

2.1 Site Geology

Soil at Site S-4 was found to be heterogeneous in nature, containing nonuniform layers of sand, gravel, silt, and clays. The site was characterized as containing alluvial sediment deposits that reside on the eroded surface of the underlying Navarro clay. Caliche also was identified, occurring either as randomly distributed nodules or as concentrated layers of gravel-sized nodules. This complex geological formation contributes to fluctuating groundwater depths, variable groundwater flow patterns, dry soil areas, and the apparent "pooling" of the subsurface LNAPL contamination.

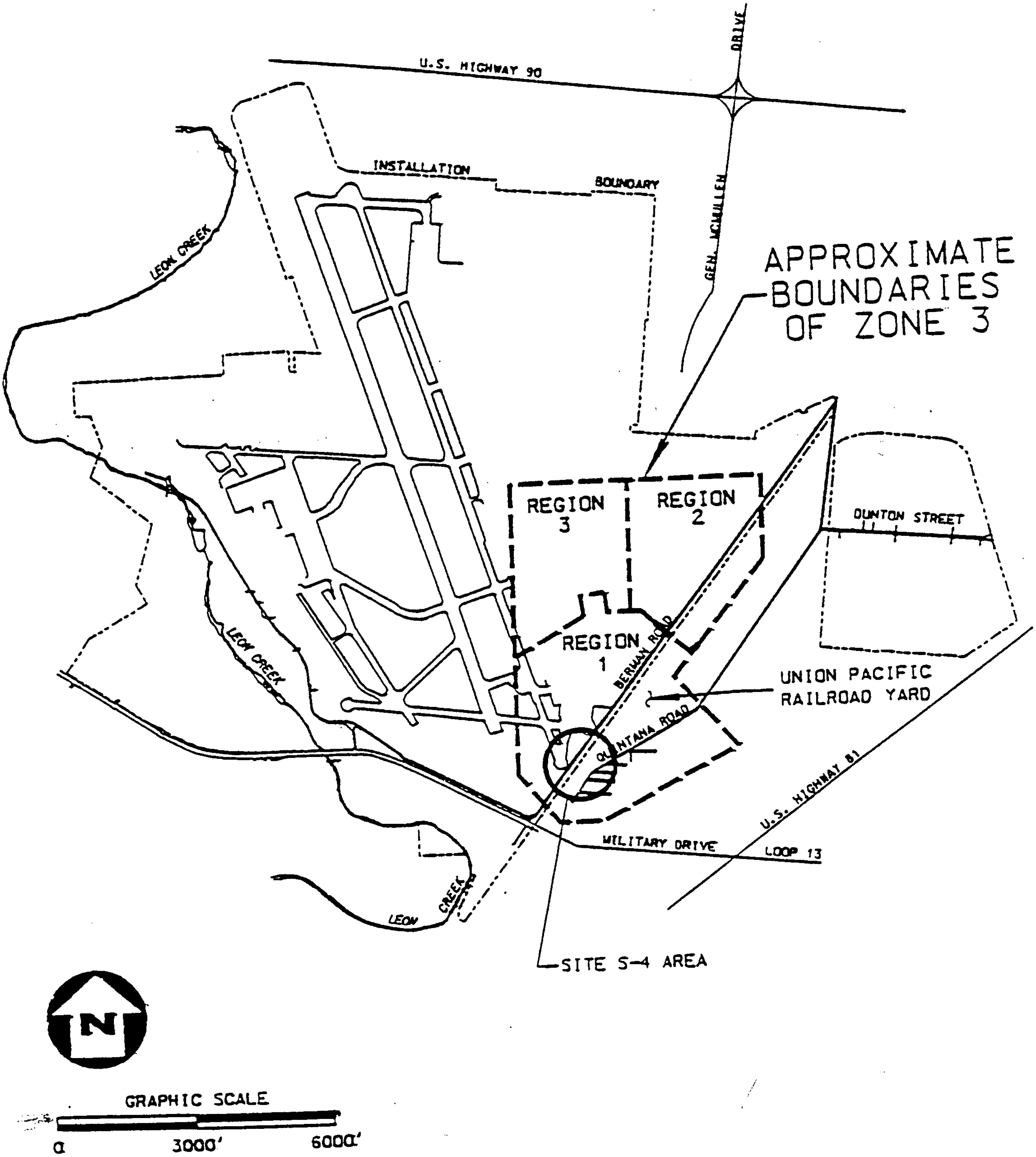

Figure 1. Schematic Diagram Showing Location of Site S-4 at Kelly AFB

2.2 Aquifer Characteristics

Groundwater at Site S-4 occurs at depths ranging from 14 to 16 ft bgs. In characterizing the aquifer, both slug and pump tests have been performed at the site. Results indicate that the average hydraulic conductivity of the aquifer is 1.87×10^{-2} cm/sec, with conductivities ranging from 1.32×10^{-1} cm/sec to 1.14×10^{-4} cm/sec (NUS 1990). The average transmissivity across the pump test area was calculated to be 158.2 ft^2/day (NUS 1990).

The Basewide Hydrogeologic Assessment (BHA) performed by NUS in 1990 indicates that the groundwater gradient at Site S-4 generally slopes to the south-southwest. Measurements from the site surveys confirm this, but the gradient is not uniform. At the center of Site S-4, the gradient decreases markedly from 0.0042 ft/ft north of Z307 to 0.0014 ft/ft between Z307 and Z301 (NUS 1990). The gradient is relatively flat in the north-south direction between wells Z337 and UP05, but it steepens again south of Z317. Also noted in the NUS 1990 report was the identification of a south-southwest depression, or "channel," in the water table that crosses Site S-4.

An elevated occurrence of the Navarro clay has resulted in a dry area at Site S-4. This area affects the groundwater flow by diverting it from a southerly flow to a southwesterly direction. The groundwater gradient and the Navarro-related dry zone have been noted for playing a critical role in shaping the resulting JP-4 plume.

2.3 Site Contamination

Benzene, toluene, ethylbenzene, and xylenes (BTEX) have been identified in the capillary fringe at Site S-4 at concentrations of 407 mg/kg with an average concentration of 100 mg/kg. In the area of UST F/371, soil gas measurements for total volatile hydrocarbons are reported as high as 64,000 ppmv with total BTEX levels of 543 ppmv.

Within the JP-4 plume, three pools of free product have been identified. These pools are centered around wells S405, Z301/Z302/Z303, and Z313/Z314. During manual bailing, well Z302 along with UP03 and Z313, consistently produced more than 3 gallons of product per half hour of continuous bailing. The field test of the bioslurper technology will likely intercept one of these 3 identified pools of free product at Site S-4. The preferred area is that associated with wells Z301/Z302/Z303 at the UPR yard off the southeastern edge of Kelly AFB (Figure 2).

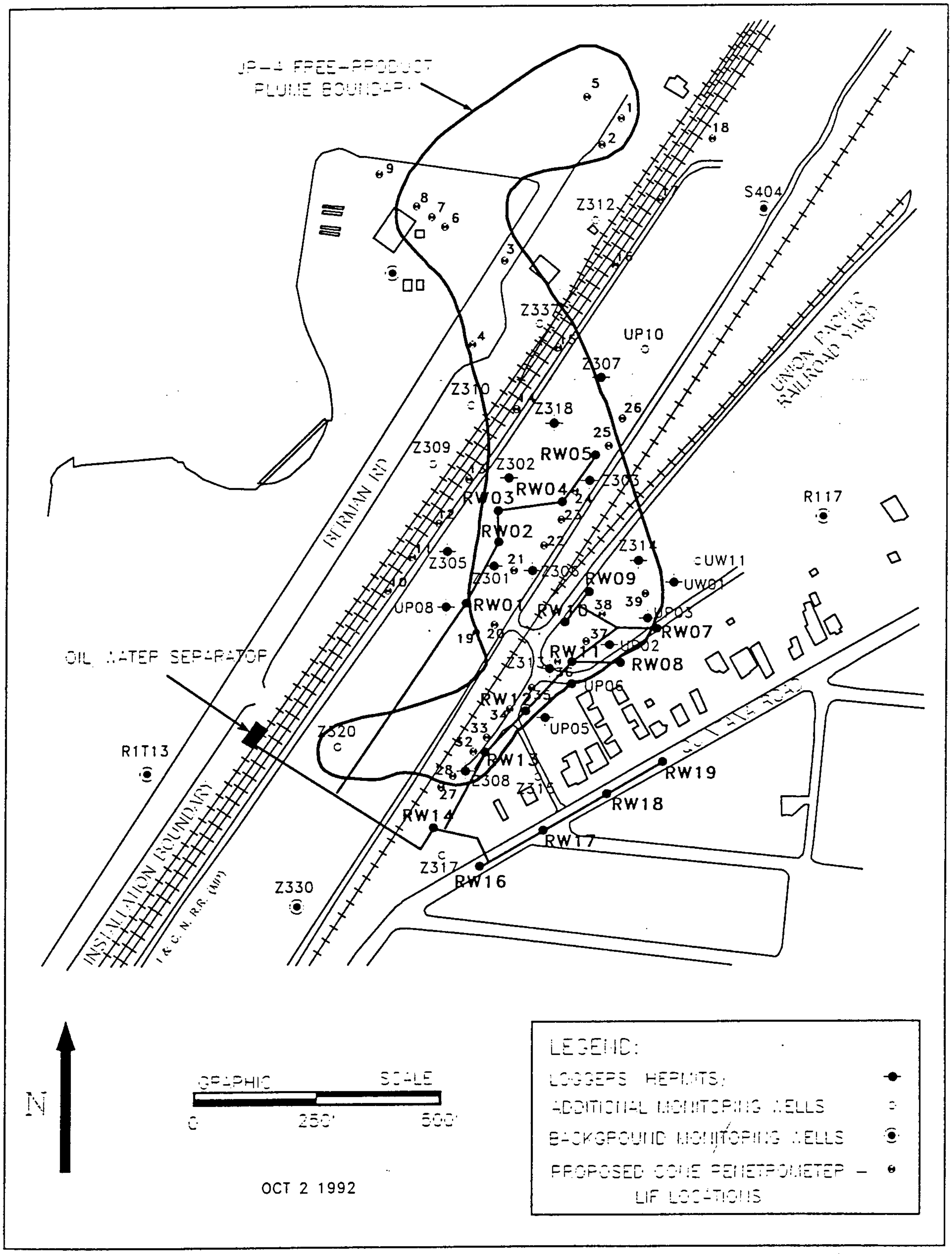

Figure 2. Location of Recovery Wells Within Site S-4

Estimates of total LNAPL contamination at Site S-4 have also been made. Based upon measured fuel thickness and the areal extent of subsurface contamination, the estimated volume of JP-4 present in the formation across the plume area ranges from 150,000 to 240,000 gallons (SAALC, 1994). Only a portion of the total volume will be impacted during the bioslurper test.

3.0 FREE-PRODUCT RECOVERY PILOT TEST METHODS

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Kelly AFB. Soil samples were not collected because the sampling equipment available could not penetrate to the capillary fringe.

3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring wells MW-8, MW-9, and MW-11 were evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a Teflon® bailer until the LNAPL thickness could no longer be reduced. A total of 2.825 L (0.75 gallons), 6.7 L (1.8 gallons), and 7.38 L (1.9 gallons) of free-phase LNAPL was removed from monitoring wells MW-8, MW-9, and MW-11, respectively, at the start of the baildown tests. The rate of increase in the thickness of the floating LNAPL layer was monitored using the oil/water interface probe for approximately 16 hr at each monitoring well.

3.2 Well Construction Details

Short-term pump tests were conducted at monitoring wells MW-11 and MW-9. Precise construction details for these monitoring wells has not yet been received from the Base. A schematic diagram illustrating general well construction details for monitoring well MW-11 is provided in Figure 3.

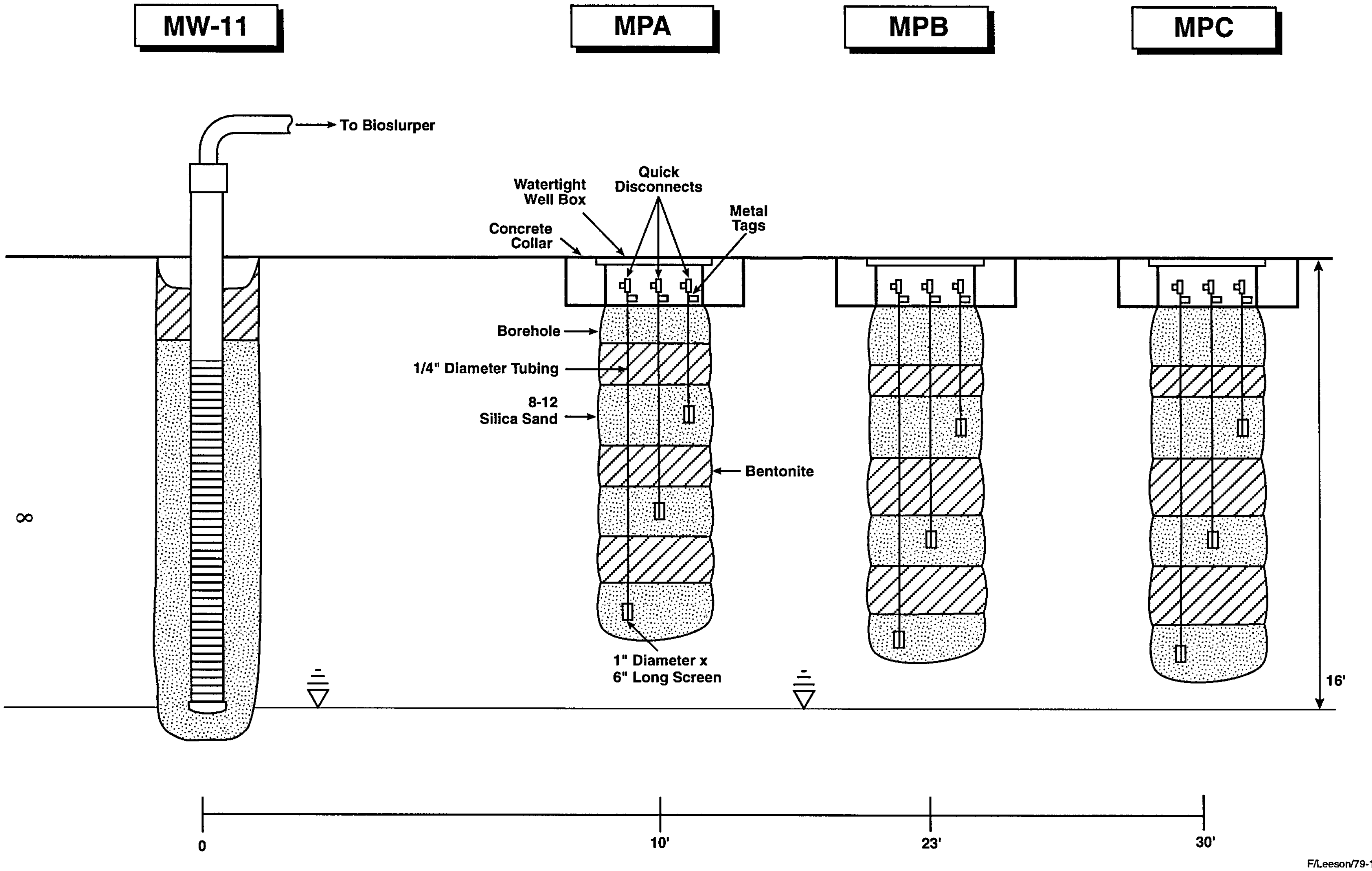

Figure 3. Schematic Diagram Showing Construction Details of Monitoring Well MW-11 and Soil Gas Monitoring Points

3.3 Soil Gas Monitoring Point Installation

Three monitoring points were installed and labeled MPA, MPB, and MPC. The locations and general constructions details of the monitoring points are illustrated in Figure 3.

Monitoring points consisted of ¼-inch tubing, with 1-inch-diameter, 6-inch-long screened areas. The annular space corresponding to the screened length was filled with silica sand. The interval from the top of the screened length to the bottom of the next screened length, as well as the interval from the ground surface to the top of the first screened length, was filled with bentonite clay chips. After placement, the bentonite clay was hydrated with water to expand the chips and provide a seal. At monitoring point MPA, the ends of the screened lengths were positioned at depths of 5.5, 9.0, and 12.5 ft bgl. At monitoring point MPB, the ends of the screened lengths were positioned at depths of 6.0, 10, and 13.5 ft bgl. At monitoring point MPC, the screened lengths were positioned at depths of 6.0, 10, and 14 ft bgl.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTech portable O_2/CO_2 meter and a GasTech TraceTechtor portable hydrocarbon meter. Oxygen concentrations were relatively high at all monitoring points, although TPH concentrations also were high (Table 1), indicating that microbial activity may be fairly low or that oxygen levels could be elevated from installation activities. Results from the in situ respiration test will provide more information concerning microbial activity.

3.4 LNAPL Recovery Testing

3.4.1 System Setup

A100 is a 7.5 Hp

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 10-hp liquid ring pump), filter box, oil/water separator, and required support equipment were carried to the test location on a trailer. The trailer was located near the monitoring well, the well cap was removed, a well seal was placed on the top of the well, and the drop tube was lowered into the well. The drop tube was attached to the vacuum pump. Different configurations of the well seal and the placement depth of the drop tube allow for simulation of skimmer pumping, operation in the bioslurping configuration, or simulation of drawdown pumping. Extracted soil gas was treated through an internal combustion engine (ICE). Data from the ICE is

Table 1. Initial Soil-Gas Compositions

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
MPA	5.5	20.0	0.25	4,200
	9.0	19.5	0.25	9,200
	12.5	11.0	7.0	>20,000
MPB	6.0	NM	NM	NM
	10	16.0	0.5	>20,000
	13.5	1.0	1.0	>20,000
MPC	6.0	15.0	0.5	>20,000
	10	16.0	0.5	>20,000
	14	10.0	1.0	>20,000

provided in Appendix B. Extracted groundwater was treated by passing the recovered fluid through the filter box, the oil/water separator, and a 325-gallon settling tank. The treated groundwater was then discharged to the Base Industrial Wastewater Treatment Plant.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is provided in Appendix C. All site data and field testing information were recorded in a field notebook and then transcribed onto pilot test data sheets provided in Appendix D.

3.4.2 Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The liquid ring pump was used to conduct the skimmer pump test with the wellhead open to the atmosphere (Figure 4). The drop tube was held in position at 16.6 ft below the top of the well casing. The pump was started 1430, 11 November 1996, to begin the skimmer pump test. The test was operated for a total of 40.9 hr. The pump vacuum was approximately 22″Hg and the vapor flowrate from the well was approximately 100 scfm. The LNAPL and groundwater extraction rates were monitored throughout

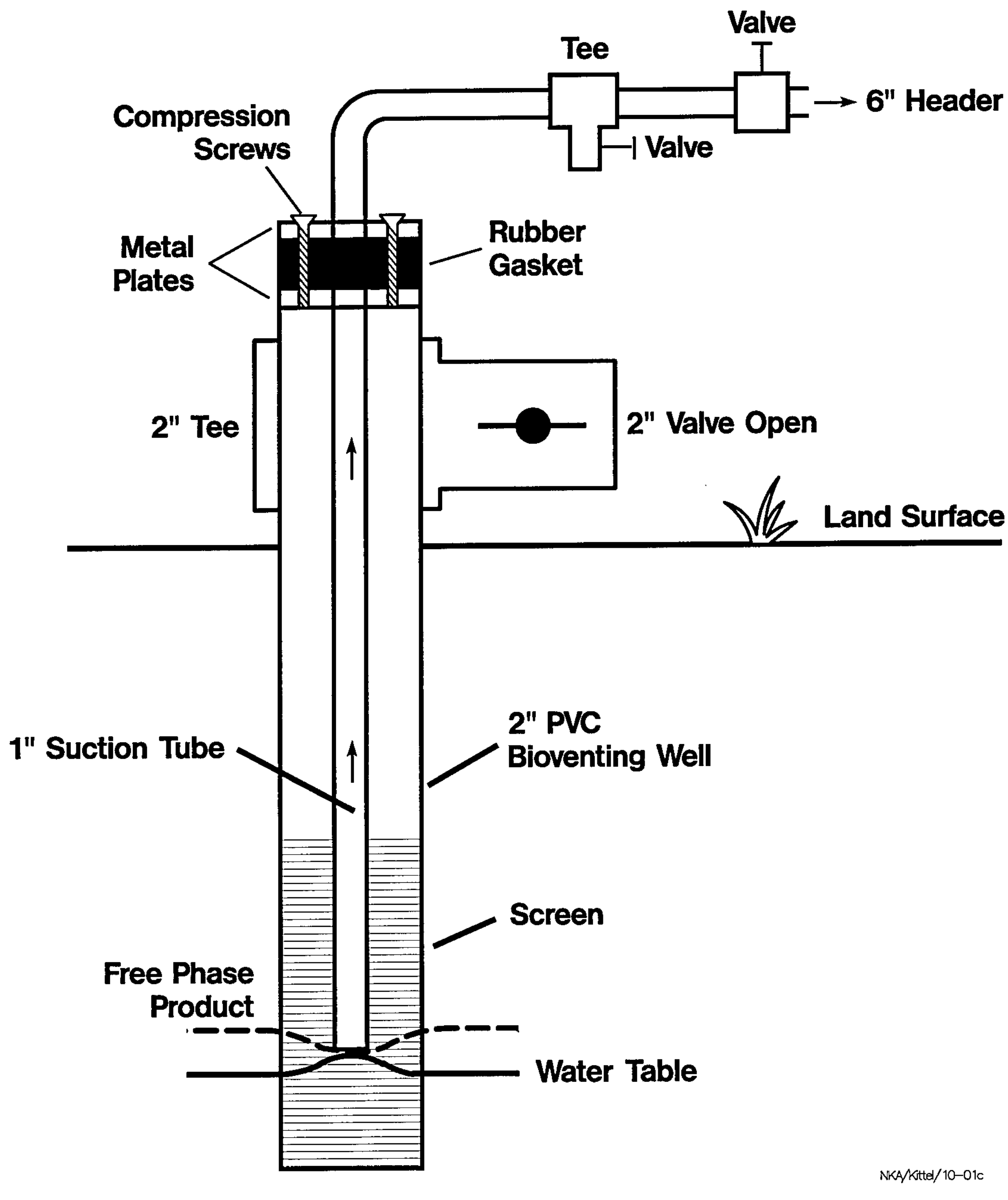

Figure 4. Drop Tube Placement and Valve Position for the Skimmer Pump Test

the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.4.3 Bioslurper Pump Test

3.4.3.1 Monitoring Well MW-11

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test at monitoring well MW-11. The LNAPL and groundwater depth were measured prior to any recovery testing. The slurper tube was set at the LNAPL/groundwater interface at a depth of approximately 15.7 ft bgl. The sanitary well seal was positioned inside the well, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 5). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump was started at 1119, 14 November 1996, to begin the bioslurper pump test. The test was initiated approximately 4 hr after the skimmer pump test and was operated for 117.5 hr. The pump vacuum was approximately 26″Hg, the vapor flowrate from the well was approximately 72 scfm, and the well vacuum was approximately 19″H_2O, and the drop tube vacuum was approximately 19″Hg. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. The data sheets are provided in Appendix D.

An LNAPL sample was collected at 1300, 17 November 1997, from the oil/water separator during the bioslurper pump test and was labeled K-LNAPL-1. The sample was sent to Alpha Analytical, Inc., in Sparks, Nevada for analysis of BTEX.

3.4.3.2 Monitoring Well MW-9

Upon completion of the bioslurper pump test at monitoring well MW-11, preparations were made to begin the bioslurper pump test at monitoring well MW-9. The LNAPL and groundwater depth were measured prior to any recovery testing. The drop tube was set at the LNAPL/groundwater interface at a depth of 17.8 ft below top of well casing. The sanitary well seal was positioned inside the well, sealing the wellhead and allowing the pump to establish a vacuum in the well. A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump was started at 1308, 19 November 1996, to begin the bioslurper pump

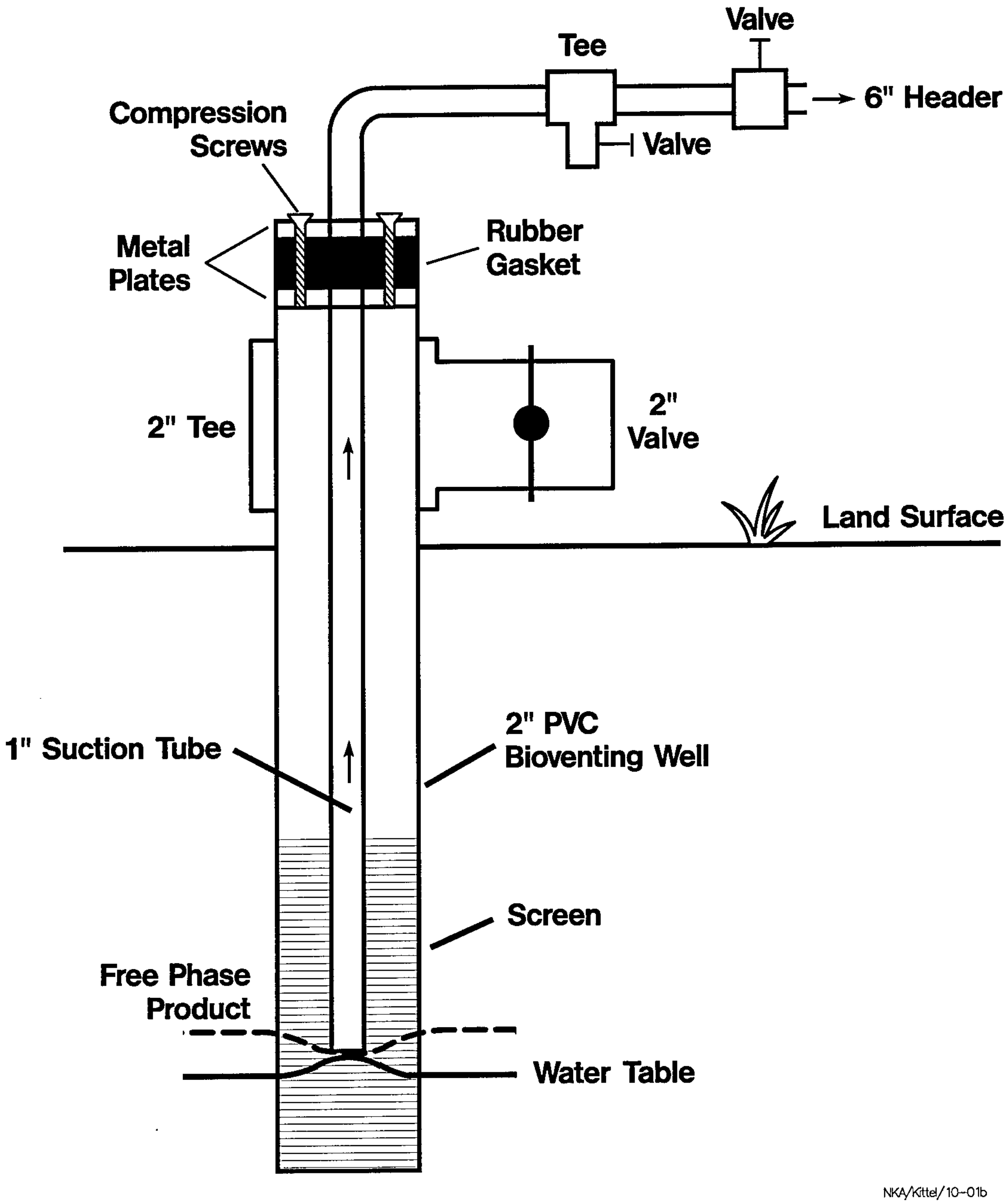

Figure 5. Drop Tube Placement and Valve Position for the Bioslurper Pump Test

test. The test was initiated approximately 3 hr after the MW-11 bioslurper pump test and was operated for 23.9 hr. The pump vacuum was approximately 25.5″Hg, the vapor flowrate was approximately 82 scfm, the well vacuum was approximately 5″H_2O, and the drop tube vacuum was approximately 19″Hg. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. The data sheets are provided in Appendix D.

3.4.4 Second Skimmer Pump Test

Upon completion of the bioslurper pump test at monitoring well MW-9, preparations were made to begin the second skimmer pump test at monitoring well MW-11. Prior to test initiation, depths to LNAPL and groundwater were measured. The liquid ring pump was used to conduct the skimmer pump test with the wellhead open to the atmosphere. The drop tube was held in position at 16.5 ft below the top of the well casing. The pump was started 1445, 20 November 1996, to begin the second skimmer pump test. The test was operated for a total of 22 hr. The pump vacuum was approximately 25.5″Hg and the vapor flowrate from the well was approximately 83 scfm. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.4.5 Off-Gas Sampling and Analysis

Five off-gas samples were collected during the bioslurper pump test at monitoring well MW-11. Samples KLRPV-1 and KLRPV-2 were collected from the seal tank headspace after approximately 71.5 and 102 hr of operation, respectively. Samples KICEV-1 and KICEV-2 were collected from the ICE off-gas after approximately 72 and 102 hr of operation, respectively. Sample KICEV-SP-1 was collected from the ICE sampling port after approximately 102 hr of operation. The samples were collected in Summa® canisters and sent under chain of custody to Air Toxics, Ltd., in Folsom, California, for analyses of TPH and volatile organic compounds (VOCs), using EPA Method TO-14. Analytical reports are provided in Appendix E.

3.4.6 Groundwater Sampling and Analysis

One groundwater sample was collected during the bioslurper pump test at monitoring well MW-11 and was labeled K-W-1. The sample was collected from the outlet to the industrial treatment plant after 76.5 hr of operation. The sample was collected in a 40-mL VOA vial containing hydrochloric acid (HCl) preservative. The sample was checked to ensure no headspace was present and was then shipped on ice and sent under chain of custody to Alpha Analytical, Inc., in Sparks, Nevada for analyses of BTEX and TPH (purgeable). Analytical reports are provided in Appendix E.

3.5 Bioventing Analyses

3.5.1 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurper pump test at monitoring well MW-11. Before a vacuum was established in the extraction well, the initial soil gas pressures at the three installed monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence. Test data are provided in Appendix F.

3.5.2 In Situ Respiration Testing

Air was injected into three monitoring points for approximately 24 hr beginning on 20 November 1996. Helium was not used due to a malfunction with equipment. The setup for the in situ respiration test is described in the Test Plan and Technical Protocol a Field Treatability Test for Bioventing (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air injection. Air was injected through monitoring points MPA-12.5, MPB-13.5, and MPC-14.0. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, and TPH were monitored periodically. The in situ respiration test was terminated on 22 November 1996. Oxygen utilization

and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix G.

4.0 FREE-PRODUCT RECOVERY PILOT TEST RESULTS

This section documents the results of the site characterization, the comparative LNAPL recovery pump test, and other supporting tests conducted at Kelly AFB.

4.1 Baildown Test Results

Results from the baildown tests are presented in Tables 2 through 4. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and recovery potential. Overall, the baildown recovery tests indicated a relatively rapid rate of LNAPL recovery into the wells, with monitoring wells MW-9 and MW-11 recovering to initial levels by the end of the 16-hr baildown tests. Based on these results, pilot testing was initiated on monitoring wells MW-11 and MW-9.

4.2 LNAPL Pump Test Results

4.2.1 Initial Skimmer Pump Test Results

Only small quantities of free-phase LNAPL were recovered during the two days of skimmer pump testing, with no measurable LNAPL recovered on day 1 and 8.9 gallons/day on day 2 (Figure 6). A total of 6.3 gallons of LNAPL was recovered (Table 5). Due to the low volume recovered, the LNAPL could not be quantified until the final day of testing. Large volumes of groundwater were produced, averaging 1,500 gallons/day. There results indicate that gravity-driven recovery is minimal.

Table 2. Results of Baildown Testing in Monitoring Well MW-8

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 11/11/96-1432	16.45	15.55	0.90
11/11/96-1545	15.83	15.76	0.07
11/11/96-1545.5	15.83	15.74	0.09
11/11/96-1546	15.83	15.74	0.09
11/11/96-1546.5	15.84	15.74	0.10
11/11/96-1547	15.84	15.74	0.10
11/11/96-1548	15.85	15.74	0.11
11/11/96-1549	15.85	15.74	0.11
11/11/96-1550	15.85	15.75	0.10
11/11/96-1555	15.88	15.74	0.14
11/11/96-1615	15.92	15.73	0.19
11/11/96-1655	15.97	15.73	0.24
11/11/96-1726	15.97	15.73	0.24
11/12/96-0751	16.37	15.62	0.75

Table 3. Results of Baildown Testing in Monitoring Well MW-9

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 11/11/96-1640	18.29	16.92	1.37
11/11/96-1648	17.28	17.20	0.08
11/11/96-1648.5	17.30	17.20	0.10
11/11/96-1649	17.33	17.20	0.13
11/11/96-1649.5	17.33	17.20	0.13
11/11/96-1650	17.34	17.20	0.14
11/11/96-1650.5	17.34	17.20	0.14
11/11/96-1651	17.35	17.20	0.15
11/11/96-1651.5	17.36	17.20	0.16
11/11/96-1652	17.37	17.20	0.17
11/11/96-1652.5	17.37	17.20	0.17
11/11/96-1658	17.43	17.19	0.24
11/11/96-1703	17.47	17.17	0.30
11/11/96-1713	17.54	17.16	0.38
11/11/96-1743	17.67	17.13	0.54
11/11/96-1813	17.78	17.08	0.70
11/12/96-0750	18.37	16.93	1.44

Table 4. Results of Baildown Testing at Monitoring Well MW-11

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 11/11/96-1432	16.59	15.2132.84	1.38
11/11/96-1504	15.57	15.53	0.04
11/11/96-1504.5	15.61	15.52	0.09
11/11/96-1505	15.64	15.51	0.13
11/11/96-1505.5	15.65	15.50	0.15
11/11/96-1506	15.68	15.49	0.19
11/11/96-1506.5	15.69	15.48	0.21
11/11/96-1507	15.72	15.47	0.25
11/11/96-1507.5	15.73	15.47	0.26
11/11/96-1508	15.75	15.47	0.28
11/11/96-1509	15.78	15.47	0.31
11/11/96-1510	15.79	15.47	0.32
11/11/96-1511	15.80	15.47	0.33
11/11/96-1512	15.81	15.47	0.34
11/11/96-1513	15.83	15.46	0.37
11/11/96-1514	15.83	15.46	0.37
11/11/96-1519	15.85	15.45	0.40
11/11/96-1524	15.88	15.44	0.44
11/11/96-1534	15.92	15.43	0.49
11/11/96-1606	16.05	15.43	0.62
11/11/96-1636	16.13	15.38	0.75
11/11/96-1730	16.28	15.35	0.93
11/11/96-1800	16.33	15.33	1.00
11/12/96-0753	16.63	15.25	1.38

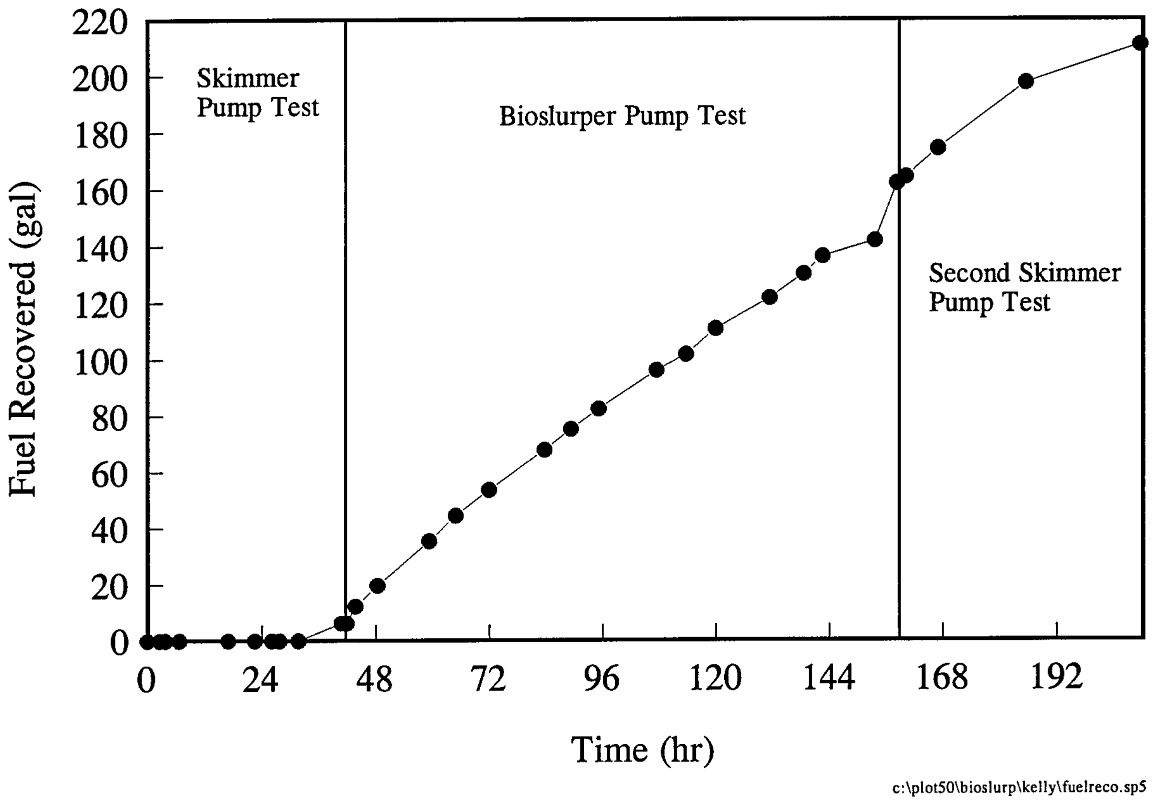

Figure 6. **LNAPL Recovery Versus Time During Each Pump Test at Monitoring Well MW-11**

Table 5. Pump Test Results at Monitoring Well MW-11

Time (Days)	Recovery Rate (gallons/day)					
	Skimmer Pump Test		Bioslurper Pump Test		Second Skimmer Pump Test	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
1	0	810	38	6,700	21	3,300
2	8.9	2,200	30	5,200	NA	NA
3	NA	NA	26	5,200	NA	NA
4	NA	NA	27	5,300	NA	NA
5	NA	NA	39	5,200	NA	NA
Average	4.5	1,400	32	5,500	21	3,300
Total Recovery (gal)	6.3	2449.6	156	26,784	19.3	3,052

NA = Not applicable.

4.2.2 Bioslurper Pump Test Results

4.2.2.1 Monitoring Well MW-11

Relatively high volumes of LNAPL was recovered during the bioslurper pump test (Table 5) (Figure 6). Bioslurper testing was conducted for approximately five days, with the LNAPL recovery rate remaining relatively constant throughout testing, with an average recovery rate of 32 gallons/day (Figure 7). A total of 156 gallons of LNAPL and 26,784 gallons of groundwater was extracted.

Soil-gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well MW-11 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were influenced at all monitoring points; however, oxygen concentrations dropped in all cases, so that by the end of the bioslurper pump tests, oxygen concentrations ranged from 1% to 8% (Table 6). These results indicate that the initial concentrations measured at the monitoring points may have been high due to oxygen diffusion into the soils during monitoring point installation. Once bioslurping was initiated, oxygen-deficient soil gas was pulled

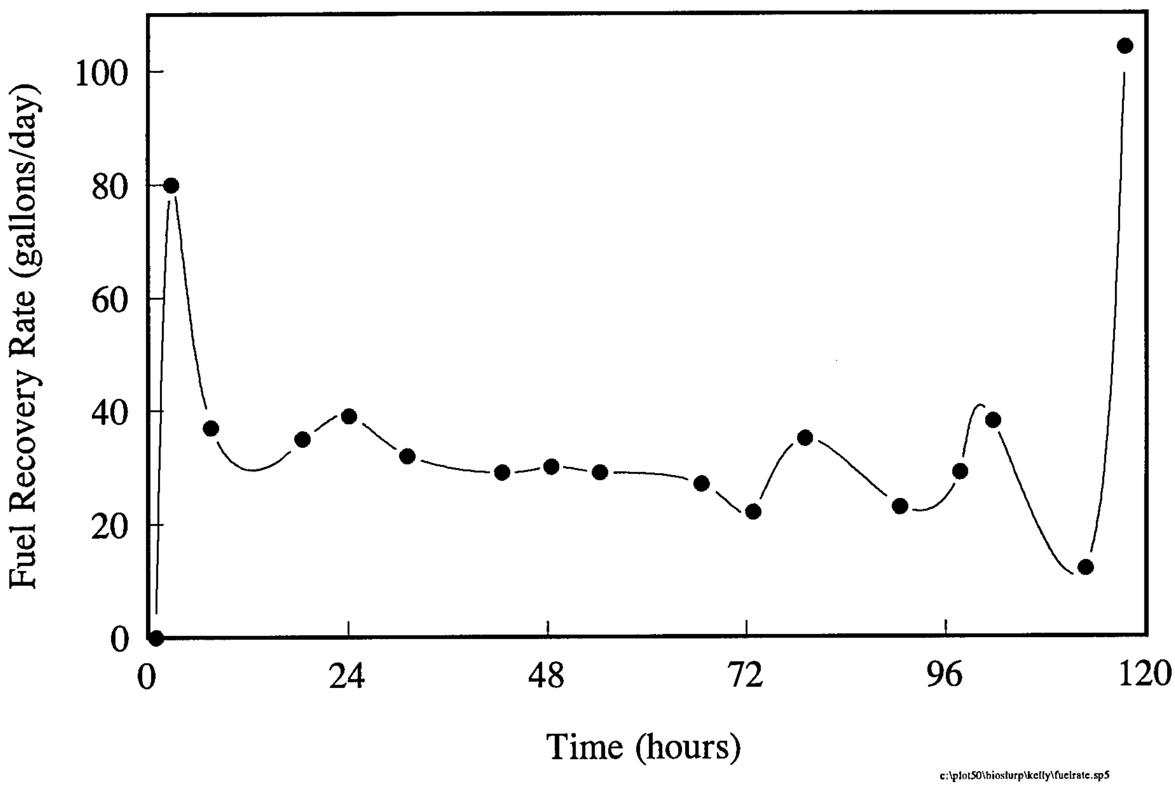

Figure 7. **LNAPL Recovery Rate Versus Time During the Bioslurper Pump Test at Monitoring Well MW-11**

Table 6. **In Situ Soil Gas Oxygen Concentrations During the Bioslurper Pump Test at Monitoring Well MW-11**

Monitoring Point	Oxygen Concentrations (%) Versus Time (hours)						
	0	35.7	47.6	56.4	71.3	81.0	97.0
MPA-5.5	20.0	15.0	13.0	10.0	8.0	2.0	2.0
MPA-9.0	19.5	14.5	0.75	14.5	9.5	10.5	8.0
MPA-12.5	11.0	1.0	0.5	10.5	1.5	1.5	1.0
MPB-6.0	NA	NA	NA	NA	NA	NA	NA
MPB-10.0	16.0	1.0	0.25	1.5	1.5	2.0	2.0
MPB-13.5	1.0	0.5	0.25	1.0	1.0	2.0	1.0
MPC-6.0	15.0	13.0	4.5	2.5	9.5	8.5	7.0
MPC-10.0	16.0	15.0	5.0	1.5	10.0	1.5	1.0
MPC-14.0	10.0	5.5	4.5	2.0	1.0	1.5	1.0

past these monitoring points, creating the drop in oxygen concentrations. Based on the soil-gas permeability test, where pressure changes were detected up to 30 ft from the bioslurper well, it is likely that these areas will become fully aerated. In short, a five day extraction time frame at 76 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

4.2.2.2 Monitoring Well MW-9

In an effort to determine if the results at monitoring well MW-11 were representative of site conditions, bioslurper testing was conducted at monitoring well MW-9. As at monitoring well MW-11, the LNAPL recovery rate (49 gallons/day) and groundwater production rate (5,400 gallons/day) were similar to those observed at monitoring well MW-11 (Table 7). The wellhead vacuum on monitoring well MW-9 (5″H_2O) was somewhat lower than that at monitoring well MW-11. Results at monitoring wells MW-11 and MW-9 appear to be representative of the site and indicate that vacuum-enhanced liquid recovery is feasible.

Table 7. Bioslurper Pump Test Results at Monitoring Well MW-9

Time (days)	Recovery Rate (gallons/day)	
	LNAPL	Groundwater
1	49	5,400
Average	49	5,400
Total Recovery (gallons)	49	5,342

4.2.3 Second Skimmer Pump Test

A second skimmer pump test was conducted to determine if results from the initial skimmer pump test were representative of gravity-driven recovery. LNAPL recovery rates were significantly higher than the initial pump test, with an average recovery of 21 gallons/day. Groundwater production also increased to an average of 3,300 gallons/day. This increase in fluid recovery could be due to enhanced mobility due to the bioslurper.

4.2.4 Extracted Groundwater, LNAPL, and Off-Gas Analyses

Results of the groundwater analyses are shown in Table 8. Contaminant concentrations were relatively low, with TPH concentrations 3.5 mg/L and all BTEX compounds below detection limits. The on-site water treatment equipment, consisting of a filter tank, oil/water separator, and clarification tanks, resulted in water effluent that is considered compatible with typical sanitary sewer discharge limits.

The results from the off-gas analyses are presented in Table 9. BTEX compounds were below detection limits, while small amounts of chlorinated compounds were detected, although these were removed by the ICE. Given a vapor flowrate from the well of 76 scfm and an average TPH concentration of 22,000 ppmv before treatment, initial hydrocarbon removal rates were approximately 960 lb/day of TPH. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication of whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is

Table 8. **BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at Monitoring Well MW-11**

Parameter	K-W-1
TPH (purgeable)	3.5
Benzene	<0.0020
Toluene	<0.0020
Ethylbenzene	<0.0020
Total Xylenes	<0.0020

NA = Not applicable.

Table 9. **Contaminant Concentrations in Off-Gas During the Bioslurper Pump Test at Monitoring Well MW-11**

Parameter	Concentration (ppmv)				
	KLRPV-1	KICEV-1	KLRPV-2	KICEV-2	KICE-SP-1
TPH as jet fuel	15,000	760	29,000	1,600	770
Benzene	<0.40	<0.071	<0.71	<0.092	<0.087
Toluene	<0.40	<0.071	<0.71	<0.092	<0.087
Ethylbenzene	<0.40	<0.071	<0.71	<0.092	<0.087
Total Xylenes	<0.40	<0.071	<0.71	<0.092	0.10
cis-1,2-Dichloroethene	2.6	<0.071	2.9	<0.092	<0.087
Trichloroethene	3.2	<0.071	2.7	<0.092	<0.087
1,2,4-Trimethylbenzene	3.0	0.13	5.4	0.34	0.35
Cyclohexane	3.2	<0.28	3.9	<0.37	<0.35
Heptane	<1.6	<0.28	2.9	<0.37	<0.35

sustained. After ICE treatment, at a vapor flowrate of 127 scfm and using an average TPH concentration of 1,180 ppmv, approximately 86 lb/day TPH was emitted during the bioslurper pump test. These results demonstrated the treatment efficiency of the ICE, with 91% destruction of TPH.

The composition of LNAPL is shown in Table 10 in terms of BTEX concentrations.

Table 10. BTEX Concentrations in LNAPL

Compound	Concentration (mg/kg)
Benzene	<500
Toluene	<500
Ethylbenzene	<500
Total Xylenes	<500

4.3 Bioventing Analyses

4.3.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is then defined as the distance from the extraction well where 0.10 inch of H_2O can be measured. Based on this definition, a radius of influence of 28 ft was determined (Figure 9).

4.3.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 11. Oxygen utilization rates were relatively high, ranging from 0.83 to 1.1 $\%O_2$/hr. Biodegradation rates ranged from 14 to 18 mg/kg-day. These results indicate that biodegradation in these locations is significant and that bioventing is feasible at this site.

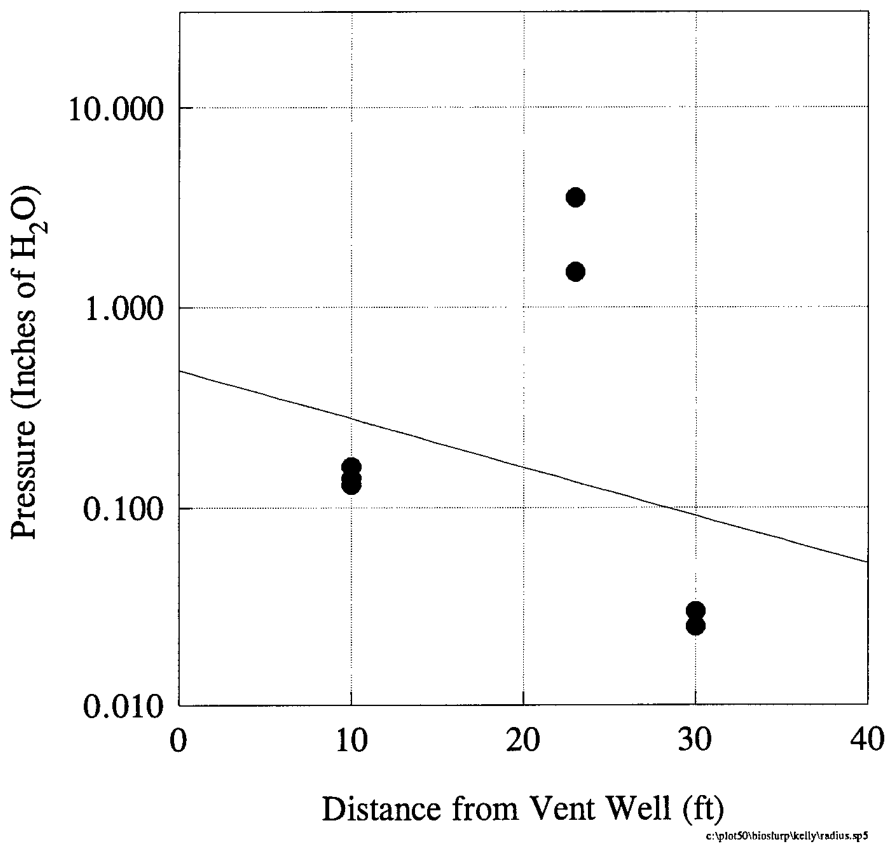

Figure 8. **Radius of Influence Determination Using Soil Gas Pressure Change Versus Distance From Extraction Well**

Table 11. In Situ Respiration Test Results

Monitoring Point	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPA-12.5	0.83	14
MPB-13.5	1.1	18
MPC-14.0	0.98	16

5.0 DISCUSSION AND CONCLUSIONS

The main objectives of the field pilot test at Kelly AFB were to determine if LNAPL recovery is feasible and to select the most effective method of LNAPL recovery.

Baildown recovery tests were conducted at three monitoring wells: MW-8, MW-9, and MW-11. Baildown recovery tests provide a qualitative indication of the presence of mobile, free-phase LNAPL and recovery potential. Overall the baildown recovery tests indicated a relatively rapid rate of LNAPL recovery into the wells. Short-term baildown recovery resulted in LNAPL thicknesses greater than or equal to the initial apparent thicknesses at monitoring wells MW-9 and MW-11. Based on these results, pilot testing was initiated on monitoring well MW-11, with a short-term bioslurper pump test also conducted at monitoring well MW-9.

Skimmer pump testing was conducted at monitoring well MW-11 in a continuous extraction mode for 40.9 hours. Small quantities of free-phase LNAPL were recovered during the two days of skimmer pump testing, indicating that gravity-driven recovery is minimal. Bioslurper testing was conducted for five days with significantly greater recoveries than during skimmer pumping. The recovery rate during the bioslurper pump test was 38 gallons/day during the first day and dropped to 26 gallons/day by day 3; however, the recovery rate increased to 39 gallons/day by day 5. Vacuum levels in the well were relatively low at 22"H_2O. The second skimmer pump test resulted in significantly greater LNAPL recoveries than observed during the first skimmer pump test, with an average LNAPL recovery rate of 21 gallons/day. These results indicate that the vacuum-enhanced bioslurper mode may have increased the LNAPL mobility, resulting in better recovery during skimmer pumping.

Groundwater production was relatively high during skimmer pumping and bioslurping, with a total of 27,000 gallons of groundwater produced. After the groundwater flowed though a filter tank and oil/water separator, the groundwater was pumped into an industrial waste line connected to the Base Industrial Wastewater Treatment Plant. Contaminant concentrations (3.5 mg TPH/L) were compatible with typical discharge guidelines.

In an effort to determine if the results at monitoring well MW-11 were representative of site conditions, bioslurper testing was conducted at monitoring well MW-9. Similar quantities of free-phase LNAPL were recovered during this bioslurper pump test, with 49 gallons/day recovered. The wellhead vacuum on monitoring well MW-9 (5"H_2O) and groundwater production rate (5,300 gallons/day) were similar to those observed at monitoring well MW-11. Results at monitoring wells MW-11 and MW-9 appear to be representative of the site and indicate that vacuum-enhanced liquid recovery techniques are feasible.

Bioslurping also promotes mass removal in the form of in situ biodegradation via bioventing and soil-gas extraction. Vapor phase mass removal is the result of soil-gas extraction as well as volatilization that occurs during the movement of LNAPL free product through the extraction network. Given the measured vapor flowrate (76 scfm) and vapor concentrations, initial hydrocarbon removal rates were approximately 960 lb/day of TPH. Benzene concentrations were below detection limits. Thus, initially, mass removal in the vapor phase is significant. However, this short-term test does not provide a good indication as to whether these rates would be sustained. Higher vapor mass removal rates are more often sustained at those sites where liquid product recovery is sustained.

The ICE used at the site was capable of reducing TPH emissions by 91%. After ICE treatment, the TPH emissions rate was reduced to approximately 86 lb/day. No benzene was detected in the emissions.

The initial soil-gas profiles at the site displayed high total volatile hydrocarbon vapor conditions across the 5.5- to 14-ft below ground surface horizons; however, oxygen concentrations were not significantly reduced except at one monitoring point (1% oxygen at MPB-13.5'). Oxygen concentrations at other monitoring points ranged from 10% to 20%. Soil-gas concentrations were measured during the bioslurper test at monitoring points adjacent to monitoring well MW-11 to determine if the vadose zone was being oxygenated via the bioslurper action. Oxygen concentrations were influenced at all monitoring points; however, oxygen concentrations dropped in all cases, so that by the end of the bioslurper pump tests, oxygen concentrations ranged from 1% to 8%. These results indicate that the initial concentrations measured at the monitoring points may have been high due to

oxygen diffusion into the soils during monitoring point installation. Once bioslurping was initiated, oxygen-deficient soil gas was pulled past these monitoring points, creating the drop in oxygen concentrations. Based on the soil-gas permeability test, where pressure changes were detected up to 30 ft from the bioslurper well, it is likely that these areas will become fully aerated. In short, a five day extraction time frame at 76 scfm is insufficient to exchange sufficient pore volumes of soil gas to fully oxygenate the zone of influence.

In situ biodegradation rates of 14 to 20 mg/kg-day were measured at three different locations. Based on a radius of influence of 28 ft and a hydrocarbon-impacted soil thickness of 16 ft, mass removal rates via biodegradation are on the order of 48 to 69 lbs of hydrocarbon per day. Thus, mass removal rates via biodegradation could be significant. These results indicate that bioventing is feasible at this site. Air injection bioventing is preferable over bioslurping and soil vapor extraction with respect to the elimination of hydrocarbon vapor emissions.

In summary, the on-site testing at Kelly AFB included the direct testing of gravity-driven and vacuum-driven LNAPL free product recovery techniques, bioventing, physical sampling, and tests relevant to soil vapor extraction. LNAPL recovery was most significant under vacuum-enhanced conditions; therefore, bioslurping is recommended at this site provided long-term treatment of groundwater is economically feasible. Vapor phase mass removal rates measured during bioslurper testing may be the result of soil gas removal (i.e., SVE) or volatilization during liquid entrainment. The generation of off-gas is undesirable and sustained rates of off-gas discharge cannot be estimated accurately from this test. The in situ respiration test and vadose zone radius of influence testing demonstrate that bioventing is feasible at this site.

6.0 REFERENCES

Battelle, 1995. Test Plan and Technical Protocol for Bioslurping. Report prepared by Battelle Columbus Operations for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. Test Plan and Technical Protocol for a Field Treatability Test for Bioventing (Rev. 2). Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc., for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT KELLY AFB, TEXAS

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT KELLY AIR FORCE BASE, TEXAS (A002)
CONTRACT NO. F41624-94-C-8012

FINAL

to

U.S. Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
8001 Arnold Drive
Building 642
Brooks AFB, TX 78235

for

Kelly AFB
SA-ALC/EMR

June 6, 1995

by

Battelle
505 King Avenue
Columbus, OH 43201

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FINAL

U.S. Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
Brooks AFB, TX

June 6, 1995

1.0 INTRODUCTION

The Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division is conducting a nationwide application of an innovative technology for free-product recovery and soil bioremediation. The technology tested in the Bioslurper Initiative is vacuum-enhanced free-product recovery/bioremediation (bioslurping). The field test and evaluation are intended to demonstrate the initial feasibility of bioslurping by measuring system performance in the field. The Bioslurper Initiative has been designed to evaluate the effectiveness of bioslurping as a light, nonaqueous-phase liquid (LNAPL) recovery technology relative to conventional gravity-driven LNAPL recovery technologies. System performance parameters, mainly free-product recovery, will be determined at numerous sites. Field testing will be performed at many sites to determine the effects of different organic contaminant types and concentrations and different geological conditions on bioslurping effectiveness.

Plans for the field test activities are presented in two documents. The first is the overall Test Plan and Technical Protocol for the entire program, titled *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). The overall Test Plan and Technical Protocol is supplemented by plans specific to each test site. The concise site-specific plans communicate vapor and aqueous discharge rates for complying with regulatory requirements specific for the base to base personnel.

The overall Test Plan and Technical Protocol was developed as a generic plan for the Bioslurper Initiative to improve the accuracy and efficiency of Test Plan preparation and ensure consistent data collection across all test sites. The field program requires installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. The basic methods to be applied from site to site do not change. Preparation and review of the overall Test Plan and Technical Protocol allows efficient documentation and review of the basic approach to the test program. Peer and regulatory review were performed for the overall Test Plan and Technical Protocol to ensure the credibility of the overall program.

This letter report is the site-specific Test Plan for the field testing approach at Kelly Air Force Base (AFB), Texas. It was prepared based on site-specific information received by Battelle from Kelly AFB and other pertinent site-specific information to support the generic Test Plan and Technical Protocol.

Site-specific information for Kelly AFB identifies at least three areas at Site S-4 within Zone 3 where JP-4 free product exists. Maximum product thickness was measured at monitoring well Z302 beneath the Union Pacific Railroad (UPR) yard off the southeastern edge of Kelly AFB. This area is considered to

be the most likely candidate for the bioslurper field test, with one of the existing recovery wells (RW02, RW03, or RW04) expected to be used. If this area is found to be unsuitable, then alternative sites include the area around monitoring well S405, which is up gradient of the underground storage tank (UST) area F/367, and the area northwest of Quintana Road in the vicinity of monitoring wells Z313 and Z314, using an existing recovery well (RW09, RW10, or RW11).

In order to supplement existing site characterization data and bioslurper application, the AFCEE/ERT will mobilize a cone penetrometer equipped with a laser-induced fluorescence sensor (CPT-LIF). The CPT-LIF will provide continuous lithological and laser induced fluorescence profiling. The laser-induced fluorescence sensor provides useful information on fuel contaminant distribution based on the characteristic fluorescence response of polycyclic aromatic fuel constituents (i.e., napthalenes).

2.0 SITE DESCRIPTION

The information presented in the Site Description portion of this Test Plan was obtained from the document titled, *Draft Technical Memorandum for the Quintana Road Project Site S-4* (Prepared for the U.S. Air Force Installation Program, Kelly Air Force Base, San Antonio, Texas. Submitted to the HAZWRAP Support Contractor Office, Oak Ridge, Tennessee. General Order Number 188-97381C, Task Y-03, Volume I of II Text, by NUS, 1990). This document is referenced as NUS 1990 in this Test Plan text.

Site S-4 is located at the southeastern edge of Kelly AFB in Zone 3 and extends off base across Berman Road to the UPR yard and the Quintana Road residential area (Figure 1). Within Site S-4 are active (F/367) and abandoned (F/371) UST facilities and their associated subsurface pipelines. Facility F/371 was constructed in 1943 and contained 5 USTs. These tanks were used to store JP-4 jet fuel but were taken out of service in 1984 and eventually abandoned in 1986. Approximately 2,000 ft of underground piping was removed from operation in 1982 after pressure tests indicated that the system contained extensive leaks (NUS 1990).

Subsurface contamination at Site S-4 was documented during storm drain excavations along Quintana Road by the City of San Antonio in 1985 and 1988. A fuel-like substance was observed floating on exposed groundwater in trenches excavated to a depth of 30 ft below ground surface (bgs). The LNAPL was subsequently identified as JP-4 jet fuel, based on analyses conducted by the Texas Water Commission.

Following the detection of subsurface free product, Radian Corporation conducted site surveys under the Installation Restoration Program (IRP) and subsequent surveys were preformed by NUS Corporation under the Hazardous Waste Remedial Actions Program (HAZWRAP). During these activities, site geological characteristics, groundwater movement, and extent of subsurface contamination were investigated.

2.1 Site Geology

Soil at Site S-4 was found to be heterogeneous in nature, containing nonuniform layers of sand, gravel, silt, and clays. Cross-sectional profiles of the area were generated and are presented in Appendix A along with additional geotechnical data. The site was characterized as containing alluvial sediment deposits that reside on the eroded surface of the underlying Navarro clay. Caliche also was identified,

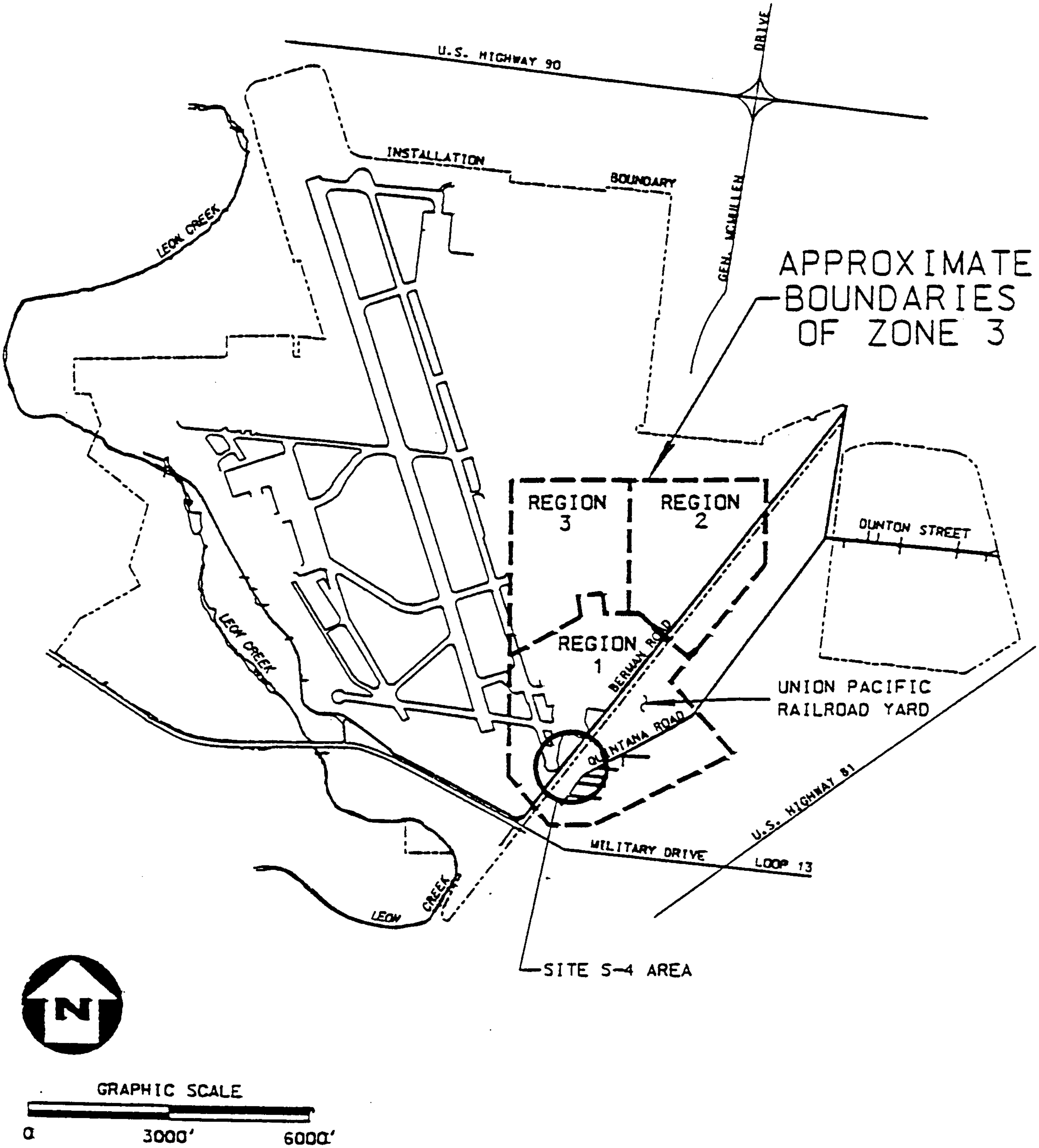


Figure 1. Schematic Diagram Showing Location of Site S-4, Kelly AFB

occurring either as randomly distributed nodules or as concentrated layers of gravel-sized nodules. This complex geological formation contributes to fluctuating groundwater depths, variable groundwater flow patterns, dry soil areas, and the apparent "pooling" of the subsurface LNAPL contamination.

2.2 Aquifer Characteristics

Groundwater at Site S-4 occurs at depths ranging from 14 to 16 ft bgs. In characterizing the aquifer, both slug and pump tests have been performed at the site. Results indicate that the average hydraulic conductivity of the aquifer is 1.87×10^{-2} cm/sec, with conductivities ranging from 1.32×10^{-1} cm/sec to 1.14×10^{-4} cm/sec (NUS 1990). Conductivity measurements at various wells are presented in Appendix B. The average transmissivity across the pump test area was calculated to be 158.2 ft^2/day (NUS 1990).

The Basewide Hydrogeologic Assessment (BHA) performed by NUS in 1990 indicates that the groundwater gradient at Site S-4 generally slopes to the south-southwest. Measurements from the site surveys confirm this, but the gradient is not uniform (Figure 2). At the center of Site S-4, the gradient decreases markedly from 0.0042 ft/ft north of Z307 to 0.0014 ft/ft between Z307 and Z301 (NUS 1990). The gradient is relatively flat in the north-south direction between wells Z337 and UP05, but it steepens again south of Z317. Also noted in the NUS 1990 report was the identification of a south-southwest depression, or "channel," in the water table that crosses Site S-4.

An elevated occurrence of the Navarro clay has resulted in a dry area at Site S-4. This area affects the groundwater flow by diverting it from a southerly flow to a southwesterly direction. The groundwater gradient and the Navarro-related dry zone have been noted for playing a critical role in shaping the resulting JP-4 plume.

2.3 Site Contamination

Benzene, toluene, ethylbenzene, and xylenes (BTEX) have been identified in the capillary fringe at Site S-4 at concentrations of 407 mg/kg with an average concentration of 100 mg/kg. In the area of UST F/371, soil gas measurements for total volatile hydrocarbons are reported as high as 64,000 ppmv with total BTEX levels of 543 ppmv.

The extent of the free-product plume at Site S-4, as of May 1990, is presented in Figure 3. The shape of the plume is thought to reflect the heterogeneous geology and the changeable groundwater flow and gradient. Within the JP-4 plume, three pools of free product have been identified. These pools are centered around wells S405, Z301/Z302/Z303, and Z313/Z314. Free-product thickness data is presented in Table 1. During manual bailing, well Z302 along with UP03 and Z313, consistently produced more than 3 gallons of product per half hour of continuous bailing. The field test of the bioslurper technology will likely intercept one of these 3 identified pools of free product at Site S-4. The preferred area is that associated with wells Z301/Z302/Z303 at the UPR yard off the southeastern edge of Kelly AFB, and the bioslurper pilot test will employ one of the existing recovery wells: RW02, RW03, or RW04 (Figure 4).

Estimates of total LNAPL contamination at Site S-4 have also been made in the final report on the *Quintama Road Project Performance Evaluation Report for the First Four Months of Recovery System Operation at Site S-4,* January 1994 (QPPE, 1994). Based upon measured fuel thickness and the areal extent of subsurface contamination, the estimated volume of JP-4 present in the formation across the plume area ranges from 150,000 to 240,000 gallons. Only a portion of the total volume will be impacted during the bioslurper test.

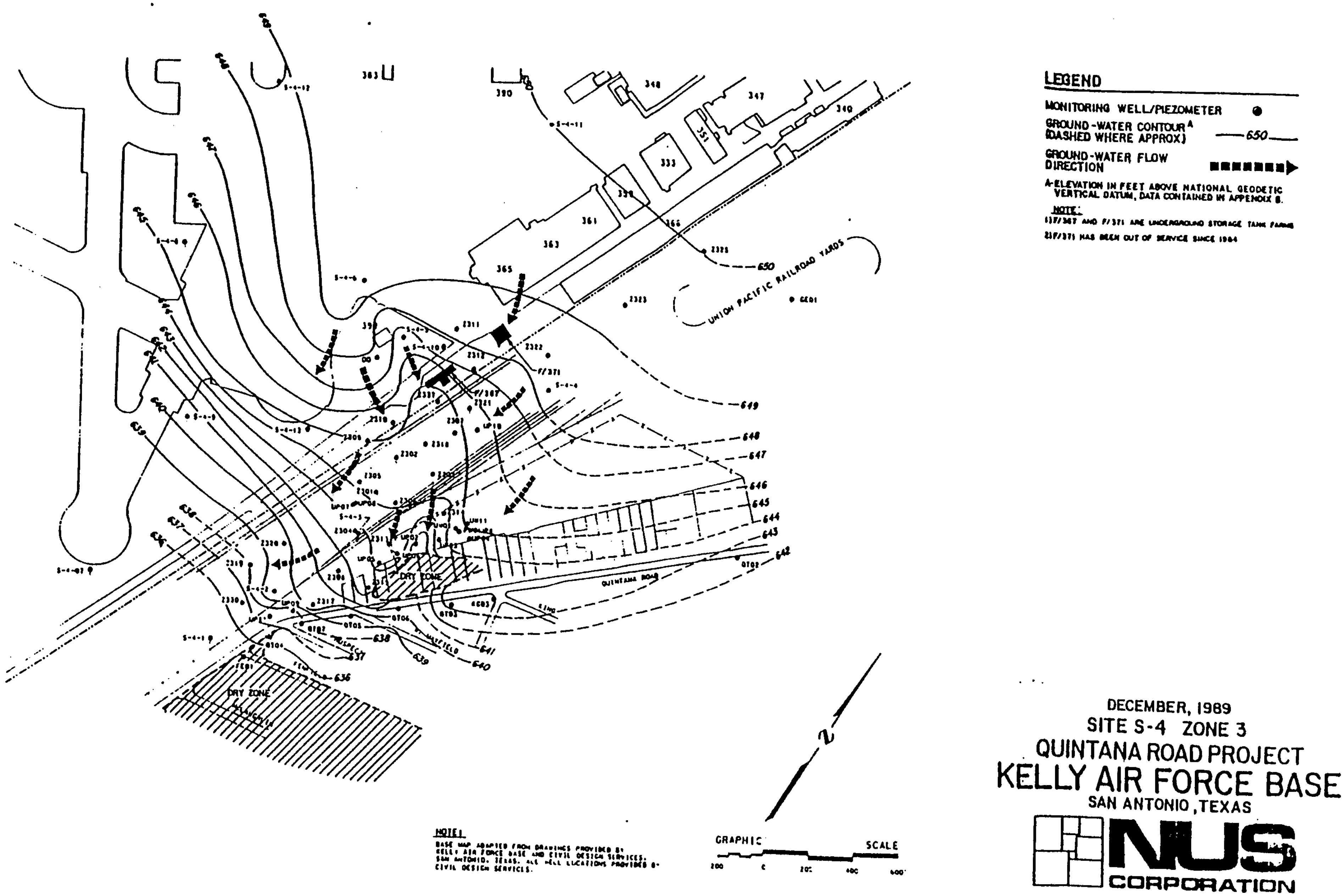


Figure 2. Groundwater Elevation and Flow Direction at Site S-4

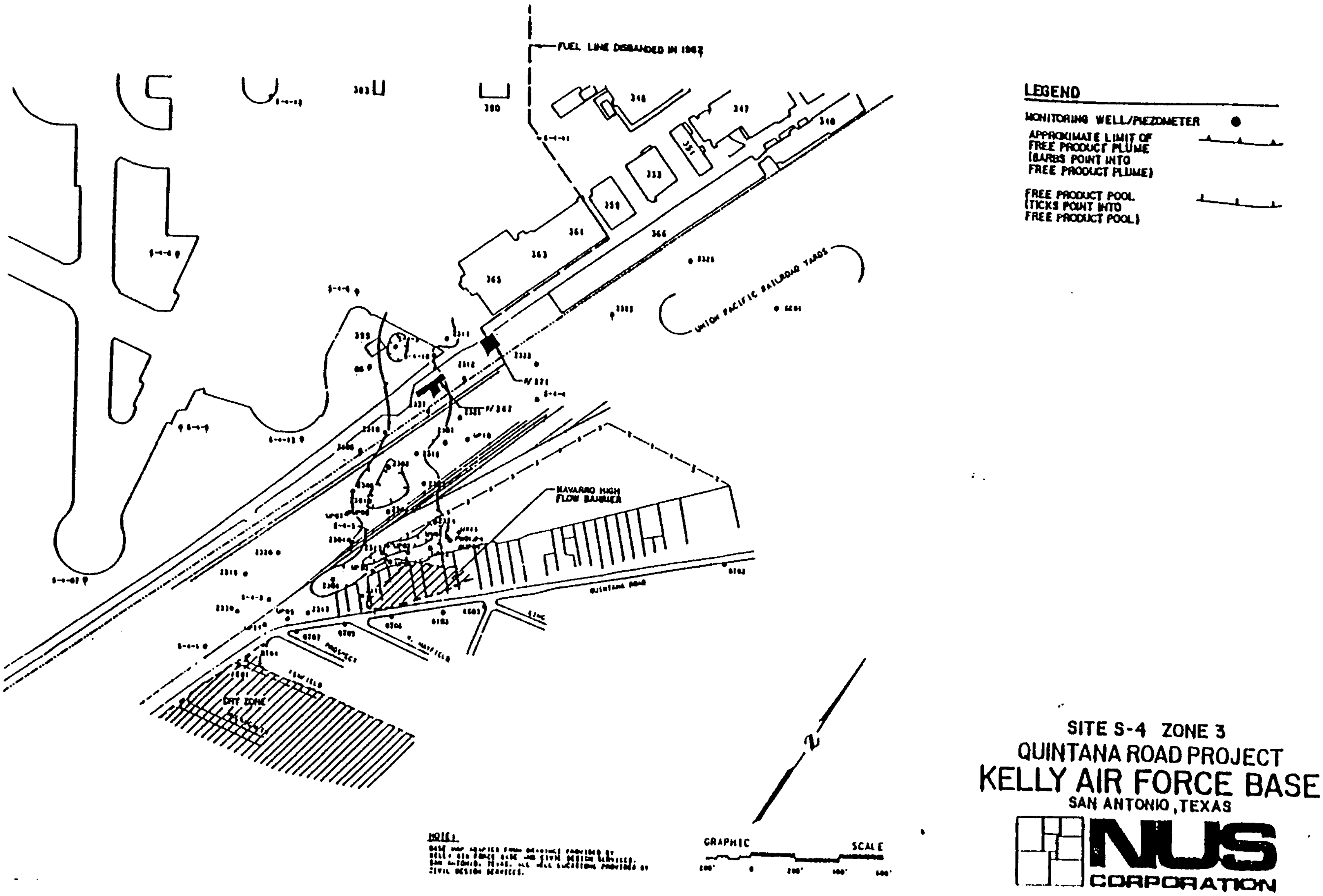


Figure 3. Free-Product Plume at Site S-4, Kelly AFB

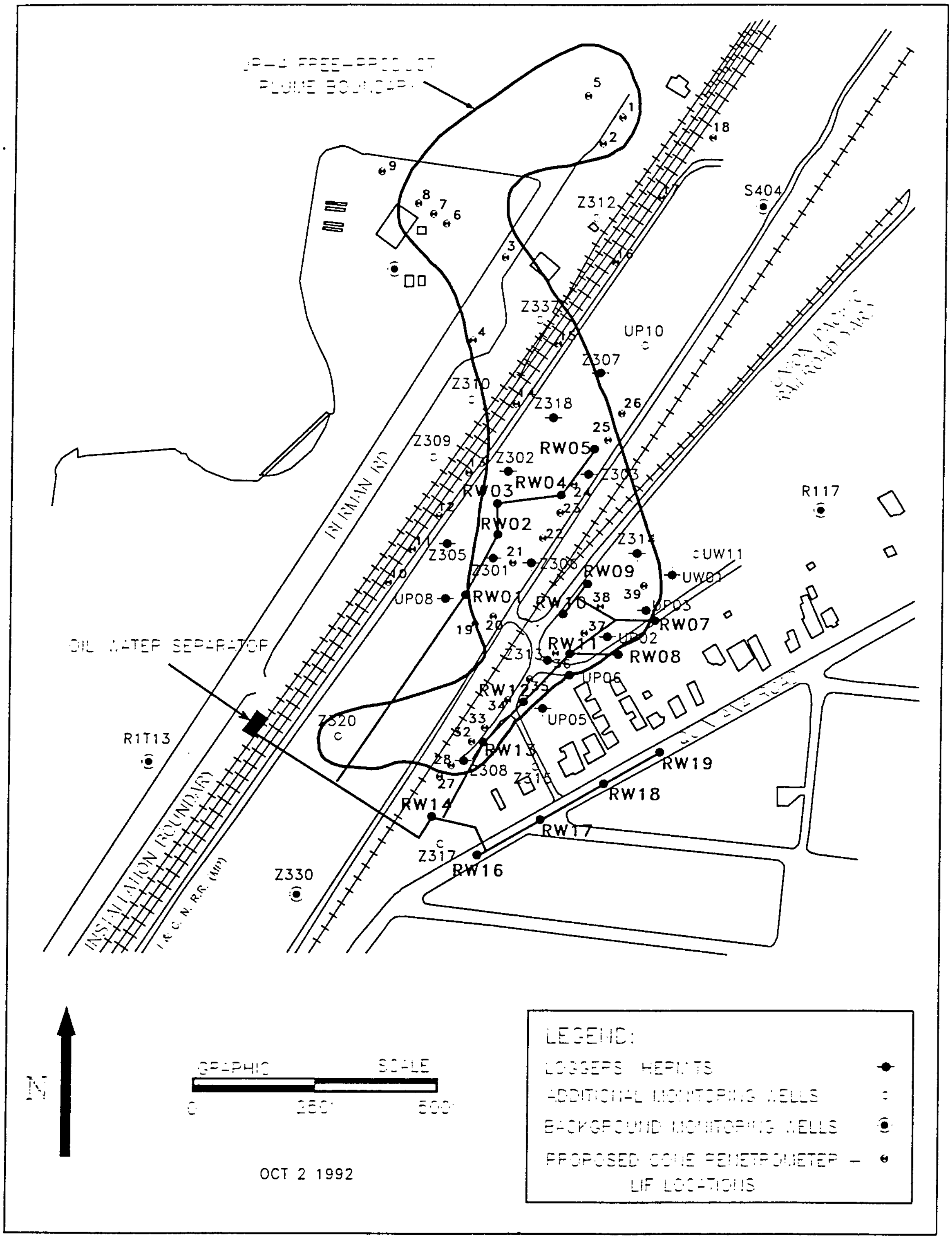


Figure 4. Location of Recovery Wells Within Site S-4

Table 1. Measured JP-4 Product Thickness at Wells Located at Site S-4

Well Number	Measured Product Thickness in Well (ft)
QT06	0.50
S405	2.25
UP02	0.49
UP03	1.13
UW09	5.70*
Z301	1.48
Z302	3.33
Z303	2.58
Z306	0.42
Z308	1.49
Z311	0.03
Z313	3.58
Z314	1.12
Z318	0.28

* = No water in well.

3.0 PROJECT ACTIVITIES

The following field activities are planned for the bioslurper pilot test at Kelly AFB. Additional details about the activities are presented in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). As appropriate, specific sections in the generic Test Plan and Technical Protocol are referenced. Table 2 shows the schedule of activities for the Bioslurper Initiative at Kelly AFB.

3.1 Mobilization to the Site

After the site-specific Test Plan is approved, Battelle staff will mobilize equipment. Some of the equipment will be shipped via air express to Kelly AFB prior to staff arrival. The Base Point of Contact (POC) will have been asked in advance to find a suitable holding facility to receive the bioslurper pilot test equipment so that it will be easily accessible to the Battelle staff when they arrive with the remainder of the equipment. The exact mobilization date will be confirmed with the Base POC as far in advance of fieldwork as is possible. The Battelle POC will provide the Base POC with information on each Battelle employee who will be on site. Battelle personnel will be mobilized to the site after it has been confirmed that the shipped equipment has been received by Kelly AFB.

3.2 Site Characterization Tests

3.2.1 Baildown Tests

The baildown test is the primary test for selection of the bioslurper test well. Baildown tests will be performed at wells that contain measurable thicknesses of LNAPL (#Z301, #Z302, and #Z303) to

Table 2. Schedule of Bioslurper Test Activities

Pilot Test Activity	Schedule
Mobilization	day 1-2
Site Characterization	day 2-3
Baildown Tests and Product/Groundwater Interface Monitoring	
Soil-Gas Survey (limited)	
Slug Tests	
Monitoring Point Installation (3 MPs)	
Soil Sampling (TPH, BTEX, physical characteristics)	
System Installation	day 2-3
Test Startup	day 3
Skimmer Test (2 days)	day 3-4
Bioslurper Vacuum Extraction (4 days)	day 6-9
Soil-Gas Permeability Testing	day 6
Skimmer Test (continued) (1 day)	day 10
In Situ Respiration Test — air/helium injection	day 10
In Situ Respiration Test — monitoring	day 11-16
Drawdown Pump Test (2 days)	day 11-12
Demobilization/Mobilization	day 13-14

estimate the LNAPL recovery potential. In most cases, the well exhibiting the highest rate of LNAPL recovery will be selected for the bioslurper extraction well. Detailed procedures for the baildown tests are provided in Section 5.6 of the generic Test Plan and Technical Protocol.

3.2.2 Soil-Gas Survey (Limited)

A small-scale soil-gas survey will be conducted to identify the best location for installation of the bioslurping system soil gas monitoring points. The soil-gas survey will be conducted in areas where historical site data indicate the highest contamination levels. These areas will be surveyed to select the locations for installation of soil-gas monitoring points. Soil-gas monitoring points will be located in areas that exhibit the following soil gas characteristics:

1. Relatively high total petroleum hydrocarbon (TPH) concentrations (10,000 ppm or greater).

2. Relatively low oxygen concentrations (between 0% and 2%).

3. Relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

To obtain further information about the soil-gas survey, consult Section 5.2 of the generic Test Plan and Technical Protocol.

3.2.3 Slug Tests

Slug tests will be performed to determine the characteristics of the aquifer where the candidate bioslurper test well is located (RW02, RW03, RW04). Slug tests will be performed using an in situ pressure transducer and a Hermit data logger to track pressure (water level) changes induced by a polyvinyl chloride capsule (slug) containing a known volume of water. Using the data collected during the slug test, the ability of the aquifer to recharge with water at Site S-4 will be examined. Additional information about the slug test method can be found in Section 5.7 of the generic Test Plan and Technical Protocol.

3.2.4 Monitoring Point Installation

Monitoring points will be installed to determine the radius of influence of the bioslurper system in the vadose zone. A general arrangement of the bioslurping well and monitoring points is shown in Figure 5.

Upon conclusion of the initial soil-gas survey and baildown tests, at least three soil-gas monitoring points will be installed to measure soil-gas changes that occur during bioslurper operation. These monitoring points should be located in highly contaminated soils within the free-phase plume and should be positioned to allow detailed monitoring of the in situ changes in soil-gas composition caused by the bioslurper system. A schematic diagram of a typical soil-gas monitoring point is shown in Figure 6. Information on monitoring point installation can be found in Section 4.2.1 of the generic Test Plan and Technical Protocol.

3.2.5 Soil Sampling

Soil samples will be collected to determine the physical and chemical composition of the soil near the bioslurper test site. Soil samples will be collected from the boreholes advanced for monitoring point installation at two or three locations at the site chosen for the bioslurper test. Generally, samples will be collected from the capillary fringe over the free product.

Soil samples from each boring will be analyzed for particle-size distribution, bulk density, porosity, moisture content, BTEX, and TPH. Section 5.5.1 of the generic Test Plan and Technical Protocol will be consulted for information on the field measurements and sample collection procedures for soil sampling.

3.3 Bioslurper System Installation and Operation

3.3.1 System Setup

After the preliminary site characterization has been completed and the bioslurper candidate well has been selected, the shipped equipment will be mobilized from the holding facility to the test site, and the bioslurper system will be assembled. Figure 7 shows a flow diagram of the bioslurper process. Figure 8 is a schematic diagram of a typical bioslurper extraction well that will be installed using an existing recovery well at Kelly AFB.

Before the LNAPL recovery tests are initiated, all relevant baseline field data will be collected and recorded. These data will include soil-gas concentrations, initial soil-gas pressures, the depth to groundwater, and the LNAPL thickness. Ambient soil and all atmospheric conditions (e.g., temperature,

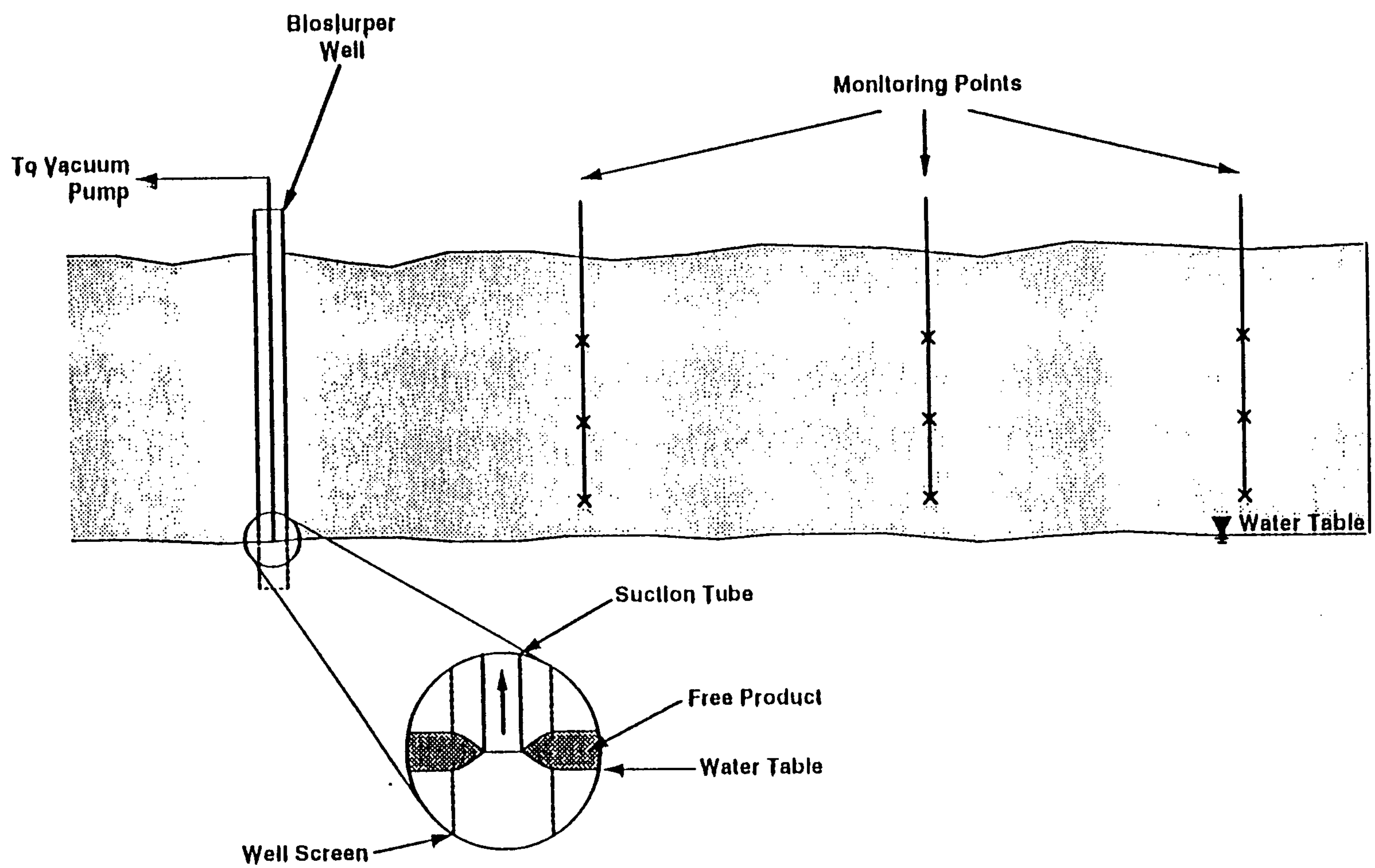


Figure 5. General Bioslurper Well and Monitoring Point Arrangement

the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.4.3 Bioslurper Pump Test

3.4.3.1 Monitoring Well MW-11

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test at monitoring well MW-11. The LNAPL and groundwater depth were measured prior to any recovery testing. The slurper tube was set at the LNAPL/groundwater interface at a depth of approximately 15.7 ft bgl. The sanitary well seal was positioned inside the well, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 5). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump was started at 1119, 14 November 1996, to begin the bioslurper pump test. The test was initiated approximately 4 hr after the skimmer pump test and was operated for 117.5 hr. The pump vacuum was approximately 26″Hg, the vapor flowrate from the well was approximately 72 scfm, and the well vacuum was approximately 19″H_2O, and the drop tube vacuum was approximately 19″Hg. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. The data sheets are provided in Appendix D.

An LNAPL sample was collected at 1300, 17 November 1997, from the oil/water separator during the bioslurper pump test and was labeled K-LNAPL-1. The sample was sent to Alpha Analytical, Inc., in Sparks, Nevada for analysis of BTEX.

3.4.3.2 Monitoring Well MW-9

Upon completion of the bioslurper pump test at monitoring well MW-11, preparations were made to begin the bioslurper pump test at monitoring well MW-9. The LNAPL and groundwater depth were measured prior to any recovery testing. The drop tube was set at the LNAPL/groundwater interface at a depth of 17.8 ft below top of well casing. The sanitary well seal was positioned inside the well, sealing the wellhead and allowing the pump to establish a vacuum in the well. A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump was started at 1308, 19 November 1996, to begin the bioslurper pump

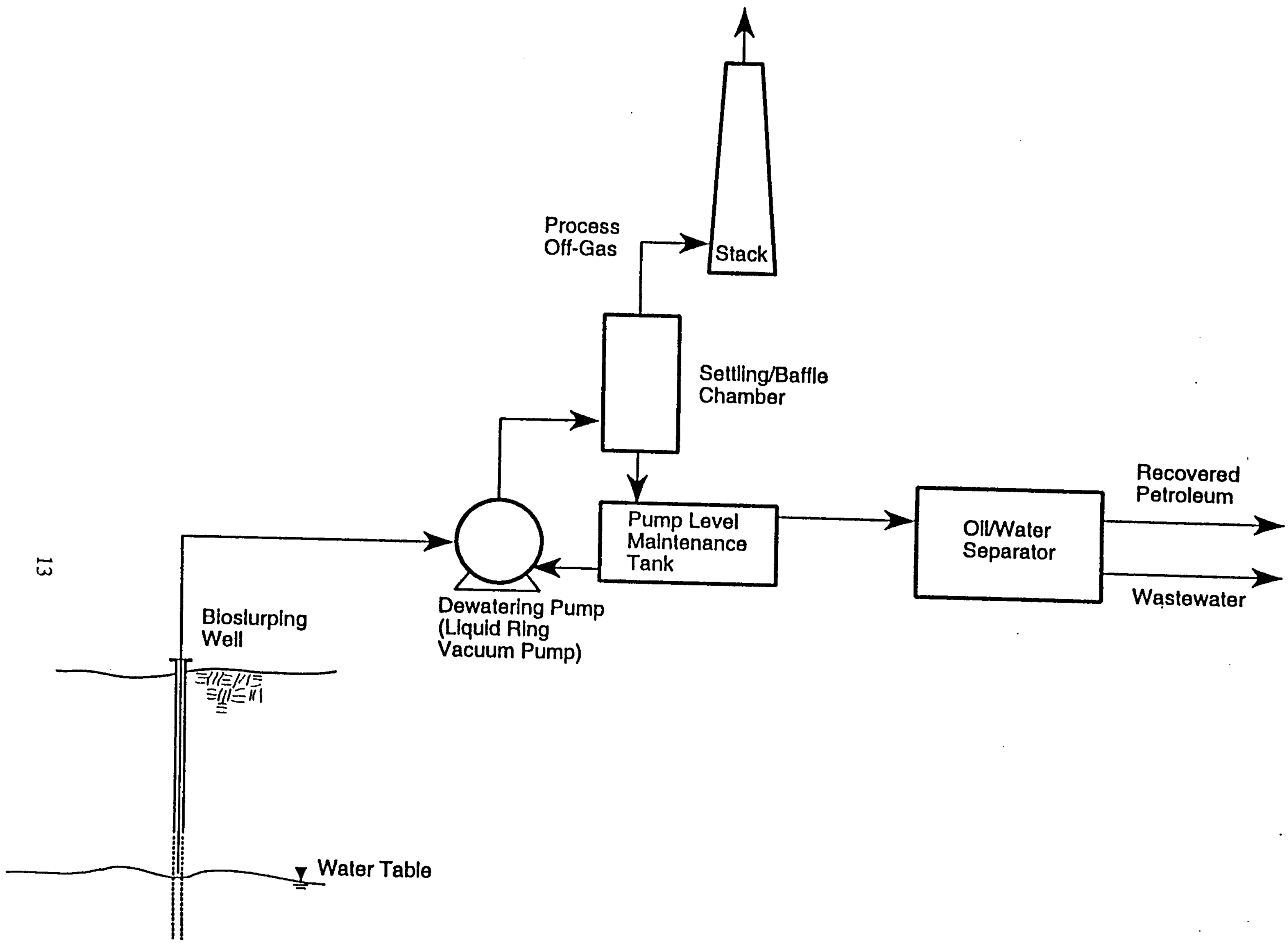


Figure 7. Bioslurper Process Flow

test. The test was initiated approximately 3 hr after the MW-11 bioslurper pump test and was operated for 23.9 hr. The pump vacuum was approximately 25.5"Hg, the vapor flowrate was approximately 82 scfm, the well vacuum was approximately 5"H_2O, and the drop tube vacuum was approximately 19"Hg. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. The data sheets are provided in Appendix D.

3.4.4 Second Skimmer Pump Test

Upon completion of the bioslurper pump test at monitoring well MW-9, preparations were made to begin the second skimmer pump test at monitoring well MW-11. Prior to test initiation, depths to LNAPL and groundwater were measured. The liquid ring pump was used to conduct the skimmer pump test with the wellhead open to the atmosphere. The drop tube was held in position at 16.5 ft below the top of the well casing. The pump was started 1445, 20 November 1996, to begin the second skimmer pump test. The test was operated for a total of 22 hr. The pump vacuum was approximately 25.5"Hg and the vapor flowrate from the well was approximately 83 scfm. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.4.5 Off-Gas Sampling and Analysis

Five off-gas samples were collected during the bioslurper pump test at monitoring well MW-11. Samples KLRPV-1 and KLRPV-2 were collected from the seal tank headspace after approximately 71.5 and 102 hr of operation, respectively. Samples KICEV-1 and KICEV-2 were collected from the ICE off-gas after approximately 72 and 102 hr of operation, respectively. Sample KICEV-SP-1 was collected from the ICE sampling port after approximately 102 hr of operation. The samples were collected in Summa® canisters and sent under chain of custody to Air Toxics, Ltd., in Folsom, California, for analyses of TPH and volatile organic compounds (VOCs), using EPA Method TO-14. Analytical reports are provided in Appendix E.

3.4.6 Groundwater Sampling and Analysis

One groundwater sample was collected during the bioslurper pump test at monitoring well MW-11 and was labeled K-W-1. The sample was collected from the outlet to the industrial treatment plant after 76.5 hr of operation. The sample was collected in a 40-mL VOA vial containing hydrochloric acid (HCl) preservative. The sample was checked to ensure no headspace was present and was then shipped on ice and sent under chain of custody to Alpha Analytical, Inc., in Sparks, Nevada for analyses of BTEX and TPH (purgeable). Analytical reports are provided in Appendix E.

3.5 Bioventing Analyses

3.5.1 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurper pump test at monitoring well MW-11. Before a vacuum was established in the extraction well, the initial soil gas pressures at the three installed monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence. Test data are provided in Appendix F.

3.5.2 In Situ Respiration Testing

Air was injected into three monitoring points for approximately 24 hr beginning on 20 November 1996. Helium was not used due to a malfunction with equipment. The setup for the in situ respiration test is described in the Test Plan and Technical Protocol a Field Treatability Test for Bioventing (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air injection. Air was injected through monitoring points MPA-12.5, MPB-13.5, and MPC-14.0. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, and TPH were monitored periodically. The in situ respiration test was terminated on 22 November 1996. Oxygen utilization

3.3.6 In Situ Respiration Tests

An in situ respiration test will be conducted after completion of the bioslurper operating tests. The in situ respiration test will involve injection of air/helium into selected soil-gas monitoring points followed by monitoring changes in concentration of oxygen, carbon dioxide, petroleum hydrocarbons, and helium in soil-gas near the injection point. Measurement of the soil-gas composition typically will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on oxygen-use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be conducted. If oxygen depletion is slow, less frequent readings will be acceptable. The oxygen utilization rate will be used to estimate the biodegradation rate at the site. Further information on the procedures and data collection for in situ respiration testing is given in Section 5.8 of the generic Test Plan and Technical Protocol.

3.3.7 Extended Testing

The AFCEE/ERT plans to implement the option of extending the operation of the bioslurper system for up to 6 months if LNAPL recovery rates are promising and viable long-term vapor and aqueous discharge requirements have been established. When the extended testing is to be performed, the Air Force will need to provide electrical power for long-term operation of the bioslurper pump. Disposition of all generated wastes and routine operation and maintenance of the system will be the Air Force's responsibility. Battelle will provide technical support during the extended testing operation.

3.4 Demobilization

Once all necessary tests have been completed at the Kelly AFB site, the equipment will be disassembled by Battelle staff and will be moved back to the holding facility, where it will remain until its next destination is determined. Battelle staff will receive this information and will be responsible for shipment of the equipment to the next site before they leave Kelly AFB.

4.0 BIOSLURPER SYSTEM DISCHARGE

4.1 Vapor Discharge Disposition

Battelle expects that the operation of the bioslurper test system at the Kelly AFB site will require a waiver or a point source air release registration and may require some additional permits. Thus, a short-term (9-10 day pumping) waiver/exclusion is requested. It can be assumed that the mass of TPH released to the atmosphere will be approximately 60 lb/day and benzene will be <1.0 lb/day. This value is based on the average discharge levels at two bioslurper test sites (Wright-Patterson AFB and Travis AFB) that are contaminated with the same type of jet fuel as that found at the Kelly AFB site. The value may vary depending on soil-gas contaminant concentrations and the permeability of the soil. The data for the TPH and benzene discharge levels at four previous bioslurper sites are presented in Table 3. The relatively high TPH discharge level at Travis AFB is partially due to the presence of more permeable soils and the resultant higher extraction rate of vapors. This extraction rate is the maximum rate a 3-hp pump will achieve and will be much lower at Kelly AFB due to the lower expected permeability of the soil. The vapor stream generated by the bioslurper system can be discharged directly to the atmosphere because of the short duration of the test and the expected low concentration levels of TPH and benzene in the stream.

Table 3. Benzene and TPH Discharge Levels at Previous Bioslurper Test Sites

Site Location	Fuel Type	Extraction Rate (scfm)	Benzene (ppmv)	TPH (ppmv)	Benzene Discharge (lb/day)	TPH Discharge (lb/day)
Wright-Patterson AFB	Jet Fuel	3	ND	595	0.0	1.0
Bolling AFB (Site #1)	No. 2 Fuel Oil	4	0.2	153	0.0003	0.009
Bolling AFB (Site #2)	Gasoline	21	370	70,000	2.3	470.1
Travis AFB	Jet Fuel	20	100	10,800	0.58	126.4
Andrews AFB	No. 2 Fuel Oil	8	16	2,000	0.001	0.2

ND = Not Detected

To ensure the safety and regulatory compliance of the bioslurper system, vapor discharge samples (TPH, O_2, and CO_2) will be collected periodically throughout the bioslurper pilot test, and field soil- gas screening instruments will be used to monitor vapor discharge concentration variability. The volume of vapor discharge will be monitored daily using air flow instruments. If state regulatory requirements will not permit the expected amount of organic vapor discharge to the atmosphere, the Base POC should inform AFCEE and Battelle so that alternative plans can be made prior to mobilization to the site. Table 4 presents information typically required to complete an air release registration form.

Table 4. Air Release Summary Information

Data Item	Air Release Information
Contractor Point of Contact	Jeff Kittel, (614) 424-6122
Contractor address	Battelle, 505 King Avenue, Columbus, OH 43201
Estimated total quantity of petroleum product to be recovered	TBD
Description of petroleum product to be recovered	JP-4 jet fuel
Planned date of test start	TBD
Test duration	9 days (active pumping)
Maximum total quantity of VOC release	~60 lb/day TPH, ~0.25 lb/day Benzene
Stack height above ground level	10 ft

4.2 Aqueous Influent/Effluent Disposition

The flowrate of groundwater pumped by the bioslurper during the short-term pilot test will be less than 5 gpm. In Texas, it may be necessary to obtain a groundwater pumping waiver or registration permit. If one is required, it is hereby requested.

Operation of the bioslurper system will generate an aqueous waste discharge that will be passed through an oil/water separator. The intention of Battelle staff will be to dispose of the wastewater by discharge to the on-site oil/water discharge tank currently in use. If existing Base wastewater channels can be used, no water discharge permits will be required.

4.3 Free-Product Recovery Disposition

The bioslurper system will recover free-phase product from the pilot tests performed at Kelly AFB. Free product recovered by the bioslurping tests will be turned over to the Base for disposal and/or recycling. Recovered free product will be transferred to existing on-site recovery tanks located within the base boundary fence. The volume of free product recovered will not be known until the tests have been performed. The maximum recovery rate for this system is 5 gpm, but the actual rate of LNAPL recovery likely will be much lower.

5.0 SCHEDULE

The schedule for the bioslurper fieldwork at Kelly AFB will depend on approval of the project Test Plan. Battelle will determine a definitive schedule as soon as possible after approval is received. Battelle will have two to three staff members on site for approximately 2 weeks to conduct all necessary pilot testing. At the conclusion of the field testing at Kelly AFB, all staff will return their Base passes and will remove all bioslurper field testing equipment from the Base before they leave the site.

6.0 PROJECT SUPPORT ROLES

This section outlines some of the major functions of personnel from Battelle, Kelly AFB, and AFCEE during the bioslurper field test.

6.1 Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at Kelly AFB will be to supply the staff and equipment necessary to perform all the tests on the bioslurper system. Battelle also will provide technical support in the areas of water and vapor discharge permitting, digging permits, staff support during the extended testing period, and any other technical areas that need to be addressed.

6.2 Kelly AFB Support Activities

To support the necessary field tests at Kelly AFB, the Base must be able to provide the following:

a. Any digging permits and utility clearances that need to be obtained prior to the initiation of the fieldwork. Any underground utilities should be clearly marked

to reduce the chance of utility damage and/or personal injury during soil-gas probe and possible well installation. Battelle will not begin field operations without these clearances and permits.

b. The Air Force will be responsible for obtaining Base and site clearance for the Battelle staff that will be working at the Base. The Base POC will be furnished with all necessary information on each staff member at least 1 week prior to field startup.

c. Access to the local sanitary sewer must be furnished so that Battelle staff can discharge the bioslurper aqueous effluent directly to the Base treatment facility.

d. Regulatory approval, if required, must be obtained by the Base POC prior to startup of the bioslurper pilot test. As stated previously, it is likely that a waiver to allow air releases or a point source air release registration will be required for emissions of approximately 60 lb/day of TPH and < 1.0 lb/day of benzene. The Base POC will obtain all necessary Base permits prior to mobilization to the site. Battelle will provide technical assistance in preparing regulatory approval documents.

e. The Base will be responsible for the disposition of all waste generated from the pilot testing. Such waste includes any soil cuttings generated from drilling, and all aqueous wastestreams produced from the bioslurper tests. All free product recovered from the bioslurper operation will be disposed of or recycled by the Base. Battelle will provide technical assistance in disposing of the waste generated from the bioslurper pilot test.

f. Before field activities begin, the Health and Safety Plan will be finalized with information provided by the Base POC. Table 5 is a checklist for the information required to complete the Health and Safety Plan. All emergency information will be obtained by the Site Health and Safety office before operations begin.

6.3 AFCEE Activities

The AFCEE POC will act as a liaison between Battelle and Kelly AFB staff. The AFCEE POC will ensure that all necessary permits are obtained and the space required to house the bioslurper field equipment is found.

The following is a listing of Battelle, AFCEE, and Kelly AFB staff who can be contacted in cases of emergency and/or required technical support during the Bioslurper Initiative tests at Kelly AFB.

Battelle POCs	Jeff Kittel	614-424-6122
	Eric Drescher	614-424-3088
AFCEE POC	Patrick Haas	210-536-4314
Kelly AFB POC	Ron Catchings	210-925-1812

Regulator POCs

Air:	Bill Brown	210-490-3096
Water:		ext. 330
UST: TNRCC		

Table 5. Health and Safety Information Checklist

<u>Emergency Contacts</u>	<u>Name</u>	<u>Telephone Number</u>
Hospital Emergency Room:		925-3227
Point of Contact:		
Fire Department:	OH Base 117	925-5119
Emergency Unit (Ambulance):		925-4549
Security:	Desk Sgt.	925-6811 or 911
Explosives Unit:	Sgt. Nieholi	925-6811 or 911
Community Emergency Response Coordinator:		911 or 925-6906
Other:		
<u>Program Contacts</u> To be notified in case of emergency		
Air Force: AFCEE Base	Patrick E. Haas	210-536-4314
	Ron Catchings	210-925-1812
Battelle:	Jeff Kittel	614-424-6122
	Eric Drescher	614-424-3088
<u>Emergency Routes</u>		
Hospital (Maps attached)		
Other:		

APPENDIX A

GEOLOGICAL CROSS-SECTIONAL PROFILES
AND A SUMMARY OF GEOTECHNICAL DATA FOR SITE S-4

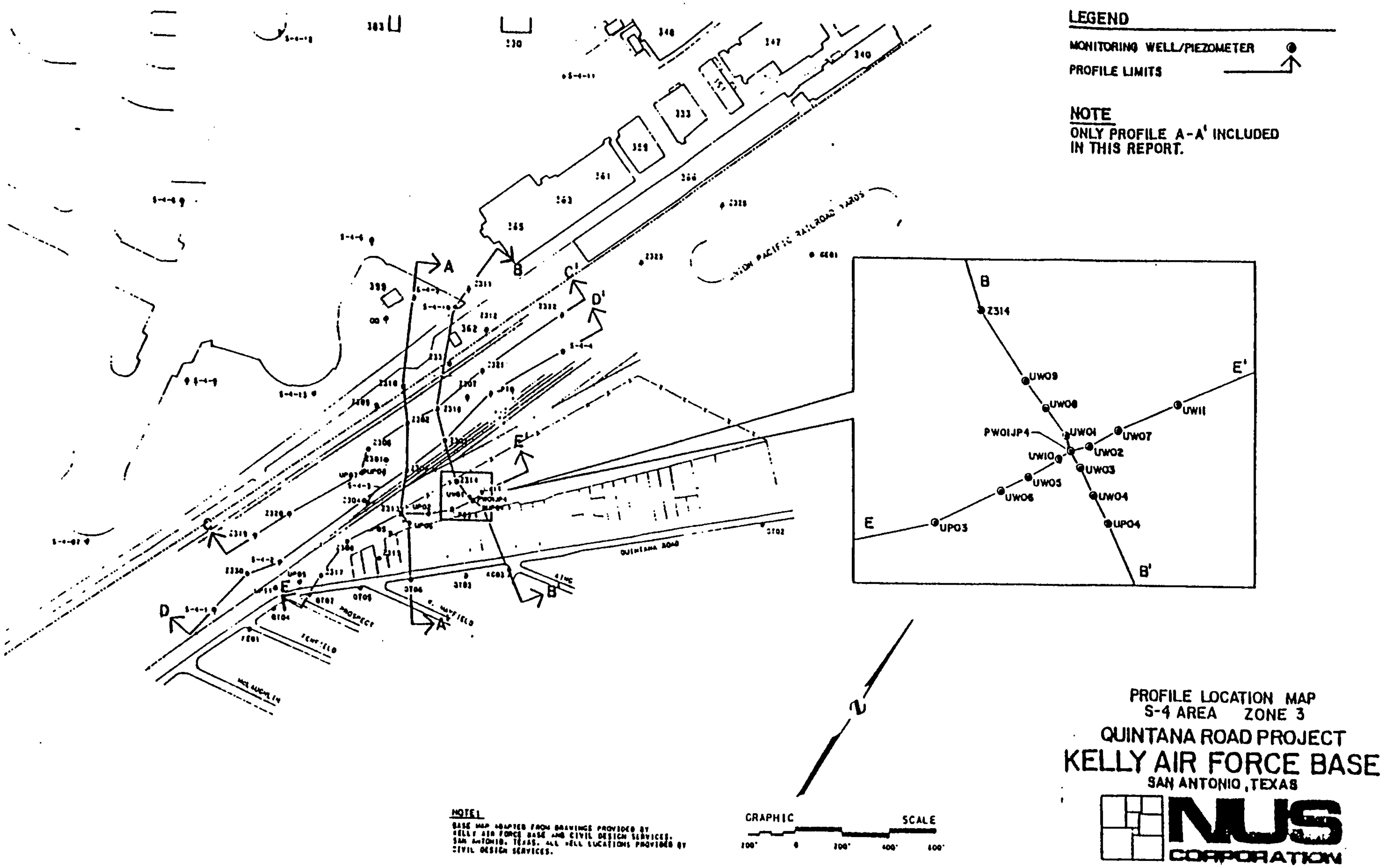


Figure A-1. Profile Location Map S-4 Area Zone 3

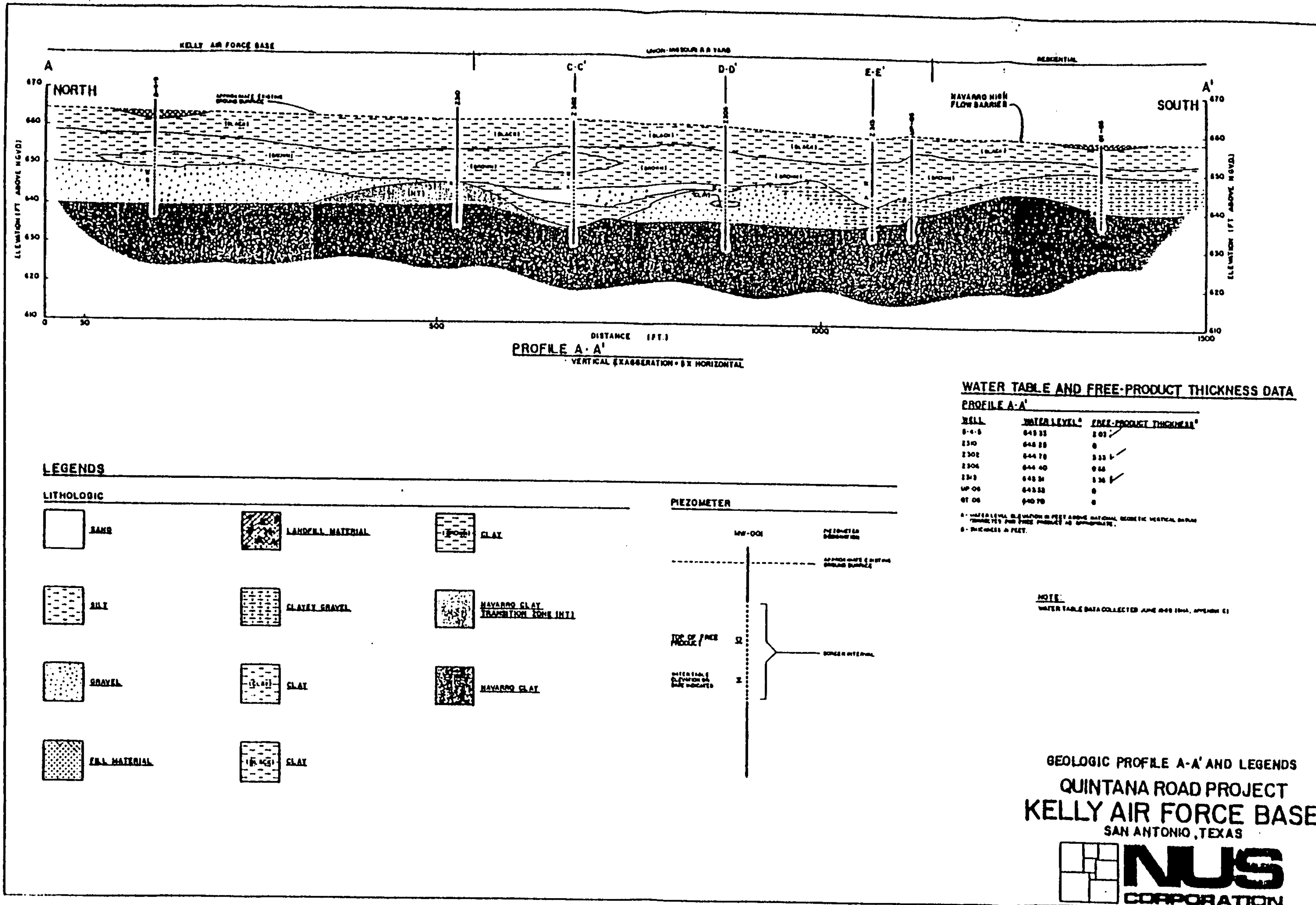


Figure A-2. Geologic Profile A-A'

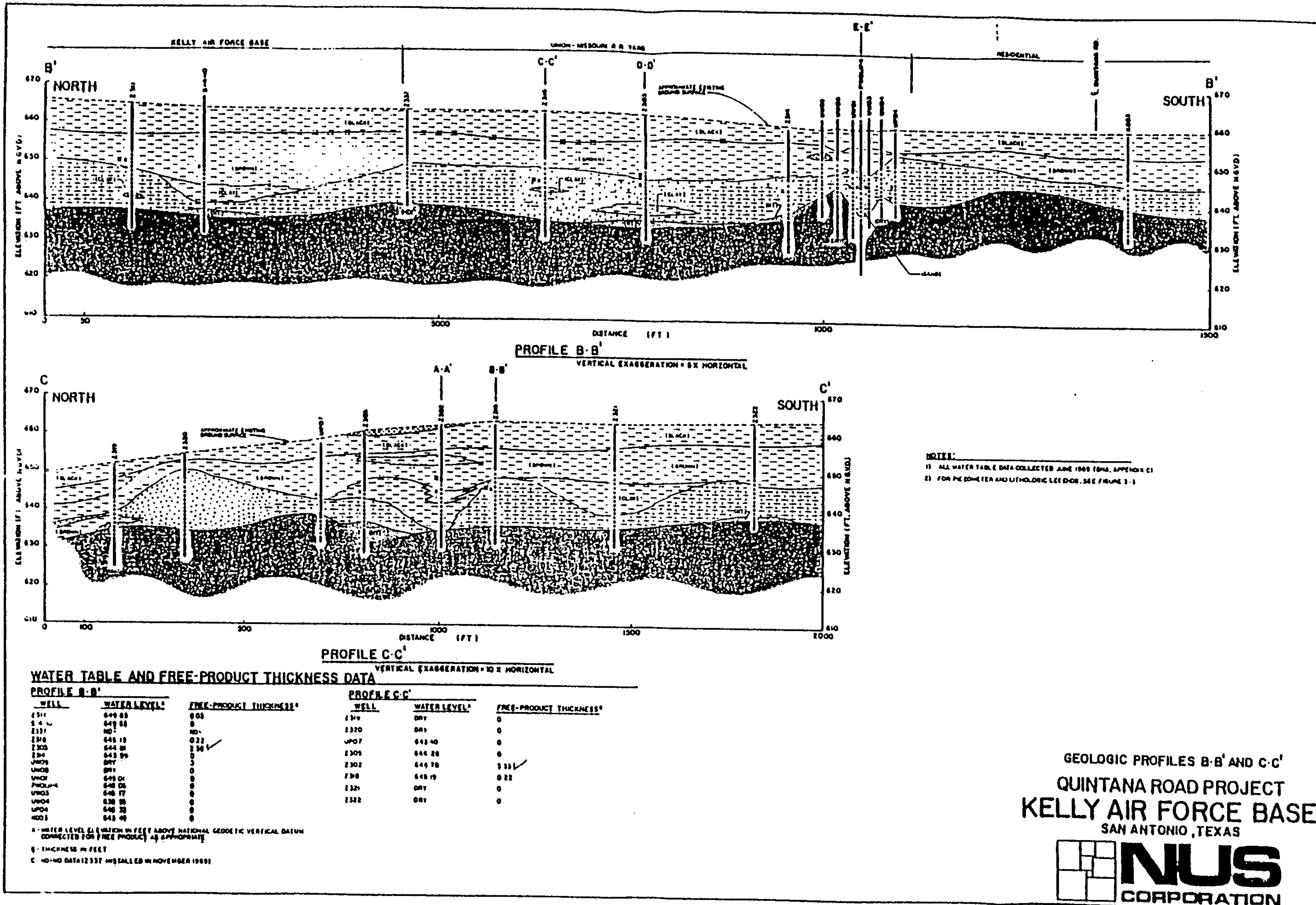
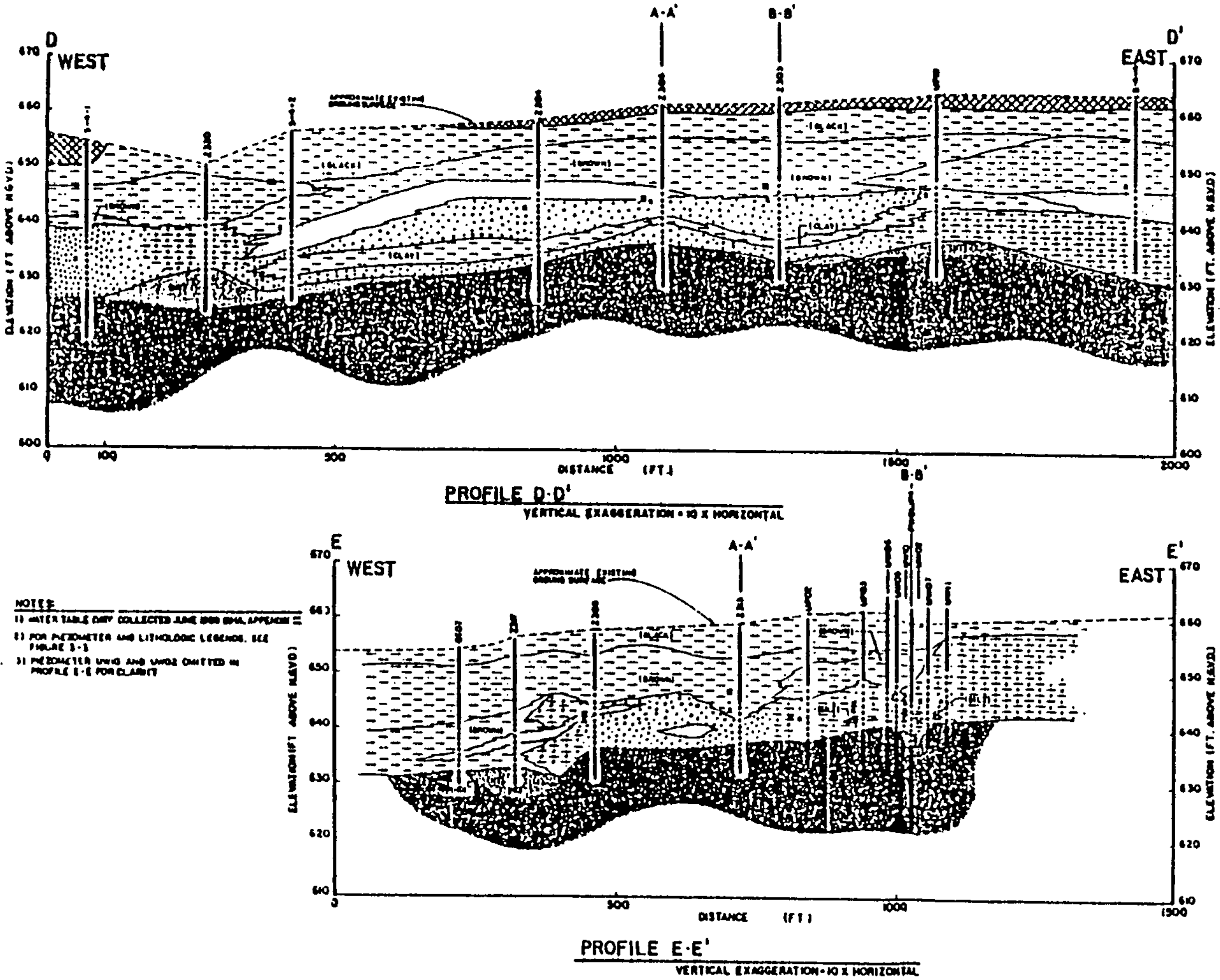


Figure A-3. Geologic Profiles B-B' and C-C'



WATER TABLE AND FREE-PRODUCT THICKNESS DATA

PROFILE D-D'

WELL	WATER LEVEL[A]	FREE-PRODUCT THICKNESS[B]
S-4-1	633.61	0
2330	DRY	0
S-4-2	639.36	0
2304	643.06	0
2306	644.40	0.66
2303	644.81	2.36
UP10	645.01	0
S-4-4	647.97	0

PROFILE E-E'

WELL	WATER LEVEL[A]	FREE-PRODUCT THICKNESS[B]
GT07	ND[C]	ND[C]
2317	ND[C]	ND[C]
2306	641.34	1.23
2313	643.11	1.36
UP02	641.95	0.17
UP03	643.53	1.15
UW06	DRY	0
UW05	DRY	0
UW10	645.06	0
PW04/P4	645.06	0
UW02	645.16	0
UW07	646.37	0
UW11	645.45	0

A - WATER LEVEL ELEVATION IN FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM CORRECTED FOR FREE PRODUCT AS APPROPRIATE.

B - THICKNESS IN FEET

C - ND = NO DATA

GEOLOGIC PROFILES D-D' AND E-E'

QUINTANA ROAD PROJECT

KELLY AIR FORCE BASE

SAN ANTONIO, TEXAS

NUS CORPORATION

Figure A-4. Geologic Profiles D-D' and E-E'

SUMMARY OF GEOTECHNICAL DATA
QUINTANA ROAD PROJECT

Sample Source	Z301	Z302	Z303	Z305	Z306	Z307	Z318
Sample Interval (ft)	15-17	17-18	17-18	17-19	17-19	25-27	5-7
Lithofacies	Brown Clay/ Gravel(b)	Brown Clay/ Gravel(b)	Brown Clay/ Gravel(b)	Clayey Gravel	Gravel	Clayey Gravel/ Gravel(b)	Black Clay/ Brown Clay(b)
Specific Gravity	2.59	2.61	2.53	2.62	2.63	2.71	2.73
% Moisture	7.7	7.5	16.0	14.9	14.9	11.2	20.4
Perm (cm/min)	0 0026	0.0018	0.0012	0.015	0.029	0.057	NR
Perm. (cm/sec)	4.33×10^{-5}	3.00×10^{-5}	2.0×10^{-5}	2.5×10^{-4}	4.83×10^{-4}	9.50×10^{-4}	1.5×10^{-7}
Unit Weight (g/cc)	1.88	1.80	1.33	1.51	1.66	1.77	1.52
pH	8.4	8.4	8.3	8.4	8.7	8.7	NR
Eh (mV)	396	396	377	399	401	408	NR
USCS(a) Classification	Sm or SC	SM or SC	ML, CL, MH, CH	SM or SC	SM or SC	GM-SM or GC-SC	NR
[illegible] Sieve (% of finer)	89 8	98.7	NR	81.7	96.0	92.0	NR
[illegible]"Sieve (% of finer)	72.2	89.1	NR	70.0	80.0	68.0	NR
#4 (% of finer)	68.4	86.7	92.9	65.2	69.5	53.3	99.7
#10 (% of finer)	61.1	80.0	87.6	54.3	42.9	38.0	97.6
#30 (% of finer)	54.8	70.9	85.5	47.9	27.2	29.2	93.1
#50 (% of finer)	46.4	58.4	82.2	43.2	19.5	21.4	92.5
#100 (% of finer)	38.1	47.5	75.0	38.0	17.3	18.4	NR
#200 (% of finer)	33.6	42.3	NR	34.5	NR	NR	86.7

Note: NR - Not reported.

(a) Unified soil classification system.
(b) The sample interval crosses the lithofacies boundary.

Table A-1. Summary of Geotechnical Data Quintana Road Project

APPENDIX B

AQUIFER CONDUCTIVITY MEASUREMENTS AND PUMP AND SLUG TEST DATA FOR SITE S-4

HYDRAULIC CONDUCTIVITY AT MONITORING WELLS IN THE QUINTANA ROAD PROJECT AREA[a]

Monitoring Well/ Piezometer	Hydraulic Conductivity cm/sec
KG-03	$1.32 \times 10^{-}$[illegible]
00	2.41×10^{-3}
PW01 JP-4	9.05×10^{-3}
QT03	3.08×10^{-3}
UP02	3.09×10^{-2}
UP03[b]	1.2×10^{-1}
UP04	1.14×10^{-4}
UP05	1.56×10^{-3}
UP07[c]	9.84×10^{-6}
UP08	1.09×10^{-3}
UP10	3.12×10^{-3}
UP11	4.49×10^{-2}
UW01	5.15×10^{-3}
UW02	1.78×10^{-2}
UW03	1.42×10^{-3}
UW07	3.56×10^{-2}
UW10	9.16×10^{-2}
UW11	2.72×10^{-2}
Z304	1.69×10^{-2}
Z305	6.59×10^{-4}
Z307	1.49×10^{-2}
Z309	7.46×10^{-4}

Monitoring Well/ Piezometer	Hydraulic Conductivity cm/sec
Z311	5.91×10^{-3}
Z312	2.66×10^{-3}
Z314	7.15×10^{-3}
Z317	3.84×10^{-3}
Z318	3.38×10^{-4}
Z319	4.35×10^{-3}
Z320	9.96×10^{-3}
Z321	4.45×10^{-3}
Z322	4.25×10^{-3}
Z323	1.06×10^{-1}
Z325	4.13×10^{-2}
Z330	5.19×10^{-3}
S-4-1	7.47×10^{-4}
S-4-2	2.7×10^{-3}
S-4-3	5.9×10^{-2}
S-4-4	1.3×10^{-3}
S-4-7	6.50×10^{-4}
S-4-8	1.22×10^{-2}
S-4-9	4.02×10^{-2}
S-4-10	2.13×10^{-4}
S-4-11	1.26×10^{-2}
S-4-12	1.34×10^{-1}

Note: All values derived from aquifer slug tests except where noted.

(a) Hydraulic conductivity was calculated using the method of Bouwer and Rice (1976).
(b) Hydraulic conductivity determined from pump test data.
(c) Piezometer installed with a five foot PVC screen within the Navarro clay.

Bouwer, H. and R.C. Rice. 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." *Water Resources Research*, V12(3).

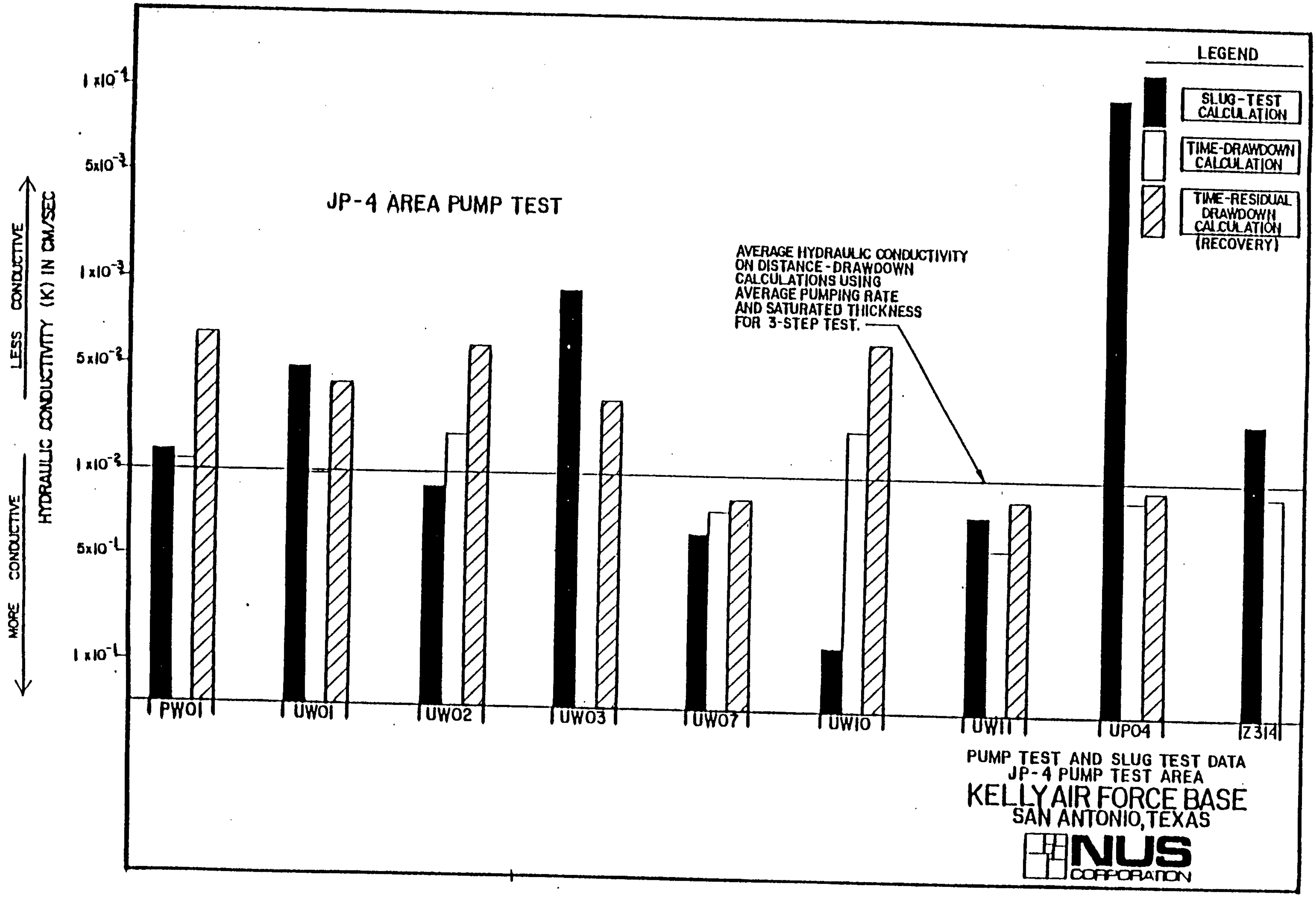


Figure B-1. Pump Test and Slug Test Data JP-4

APPENDIX B

ICE OPERATIONAL DATA

```
ESTART AT: 11/12/96 11:36:20 (11/08/96 08:36:39) S5245  V2.23 .
./12/96 11:36:23  UNIT 182
100    4.    75.F   77.F   84.F    0.   16.8   -0.7     0.    12.   12.6   99.9  0.500   0.00   115    356   1394.
ESTART AT: 11/12/96 11:37:15 (11/12/96 11:36:47) S5245  V2.23 .
/12/96 11:37:18  UNIT 182
100    4.    75.F   77.F   85.F    0.   19.0   -0.7     0.    12.   12.6   99.9  0.500   0.00   115    356   1394.
ESTART AT: 11/12/96 11:38:33 (11/12/96 11:38:12) S5245  V2.23 .
/12/96 11:38:11  UNIT 182
0    8.    75.F   77.F   85.F    0.   23.5   -0.7     0.    12.   12.1   78.2  0.544   0.00   115    356   1394.
11/12/96 11:38:36  UNIT 182
00    4.    75.F   77.F   85.F    0.   23.5   -0.7     0.    12.   12.6   99.9  0.500   0.00   115    356   1394.
ESTART AT: 11/12/96 11:40:08 (11/12/96 11:38:52) S5245  V2.23 .
11/12/96 11:40:11  UNIT 182
100    4.    75.F   77.F   86.F    0.   23.5   -0.7     0.    12.   12.6   99.9  0.500   0.00   115    356   1394.

[illegible] UNIT [illegible] 2/96 11:41:51 (11/12/96 11:40:28) S5245 [illegible] 0.700 V2.23 [illegible] 115    356   1394.
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```
ESTART AT: 11/12/96 11:44:28 (11/12/96 11:42:56) 85245  V2.23 .
11/12/96 11:44:31  UNIT 182
100     4.    75.F    77.F    86.F  100.   23.5   -0.7     0.    12.   12.6   99.9  0.500   0.00   115    356    1394.
/12/96 11:45:43  UNIT 182
100  1590.    97.F    78.F   400.F   53.   23.6   -0.7     0.    12.   13.7   10.3  0.679   0.00   115    356    1394.
11/12/96 12:00:06  UNIT 182
0  1865.   160.F   158.F   831.F   53.   23.4   -1.0     0.    14.   13.2   10.2  0.680   0.00   115    356    1394.
/12/96 12:01:33  UNIT 182
100  2329.   161.F   159.F   837.F   53.   23.4   -1.1     0.    14.   13.3   10.1  0.680   0.85   115    357    1394.
/12/96 12:02:22  UNIT 182
0  2401.   164.F   161.F   903.F   53.   23.4   -1.0     0.    14.   13.3   51.8  0.596   0.73   115    358    1394.
11/12/96 12:03:00  UNIT 182
100  2403.   165.F   164.F   917.F   53.   23.4   -1.0     0.    14.   13.3   50.3  0.599   0.72   115    358    1394.
/12/96 12:03:52  UNIT 182
0  2198.   164.F   166.F   930.F   53.   21.2   -1.0     0.    14.   13.2   54.4  0.591   0.90   115    359    1394.
11/12/96 12:04:10  UNIT 182
0  1852.   164.F   166.F   923.F   53.   17.9   -1.0     0.    14.   13.3   59.2  0.582   0.81   115    359    1394.
/12/96 12:04:49  UNIT 182
100  1843.   164.F   166.F   898.F   53.   17.9   -1.0     0.    14.   13.3   59.2  0.582   0.00   115    359    1394.
```

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

DATE / TIME / UNIT		ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	-UNITS	ENGINE HOURS
11/12/96 12:05:35 UNIT 182	100	1849.	163.F	165.F	872.F	53.	17.5	-1.0	0.	14.	13.4	53.7	0.593	0.73	115	360	1394.
11/12/96 12:06:40 UNIT 182	100	2253.	163.F	164.F	866.F	53.	21.0	-1.0	0.	14.	13.4	49.6	0.601	2.10	115	363	1395.
11/12/96 12:07:08 UNIT 182	100	2278.	164.F	165.F	887.F	53.	21.0	-0.9	0.	14.	13.5	51.6	0.597	2.46	115	364	1395.
11/12/96 12:07:40 UNIT 182	100	2236.	165.F	165.F	899.F	53.	21.0	-0.9	0.	14.	13.4	50.9	0.598	2.53	115	365	1395.
11/12/96 12:08:27 UNIT 182	100	2223.	165.F	166.F	901.F	53.	21.0	-0.9	0.	14.	13.5	49.9	0.600	2.50	115	367	1395.
11/12/96 12:09:15 UNIT 182	100	2209.	166.F	167.F	903.F	53.	21.0	-0.9	0.	14.	13.5	51.1	0.598	2.48	115	369	1395.
11/12/96 12:10:12 UNIT 182	100	2190.	166.F	167.F	909.F	53.	18.9	-0.8	18.	14.	13.5	49.5	0.601	2.50	115	372	1395.
11/12/96 12:11:03 UNIT 182	100	2200.	166.F	168.F	909.F	53.	15.6	-0.7	38.	13.	13.5	48.7	0.603	2.50	115	374	1395.
11/12/96 12:13:28 UNIT 182	100	2200.	166.F	169.F	903.F	53.	12.8	-0.5	53.	13.	13.5	50.0	0.600	2.43	115	380	1395.
11/12/96 12:14:48 UNIT 182	100	2184.	166.F	169.F	906.F	53.	12.8	-0.5	53.	13.	13.5	49.3	0.601	2.43	115	383	1395.
11/12/96 12:18:06 UNIT 182	100	2232.	165.F	170.F	892.F	53.	5.9	9.0	94.	12.	13.1	50.3	0.599	2.51	115	391	1395.
11/12/96 12:19:58 UNIT 182	100	2222.	165.F	171.F	889.F	53.	-0.4	12.8	113.	11.	13.3	52.6	0.595	2.54	115	396	1395.
11/12/96 12:27:47 UNIT 182	100	2197.	167.F	174.F	887.F	53.	-0.4	12.8	113.	12.	13.2	52.9	0.594	2.54	115	416	1395.
11/12/96 12:29:25 UNIT 182	100	2200.	167.F	174.F	888.F	53.	-0.4	12.8	113.	12.	13.2	52.0	0.596	2.55	115	421	1395.
11/12/96 12:30:00 UNIT 182	100	2210.	167.F	174.F	887.F	53.	-0.4	12.8	113.	12.	13.1	51.5	0.597	2.54	115	422	1395.
11/12/96 12:31:29 UNIT 182	100	2204.	169.F	175.F	887.F	53.	-0.4	12.9	113.	12.	13.2	50.5	0.599	2.54	115	426	1395.
11/12/96 12:42:40 UNIT 182	100	2157.	169.F	176.F	916.F	53.	-0.4	14.3	119.	11.	13.1	53.8	0.592	2.10	115	453	1395.

11/12/96 12:49:03 UNIT 182	00	2155.	168.F	175.F	934.F	53.	-0.4	15.2	122.	11.	13.1	52.9	0.594	2.22	115	467	1395.
/12/96 12:52:00 UNIT 182	100	2158.	168.F	175.F	935.F	53.	-0.4	15.4	122.	11.	13.1	52.0	0.596	2.23	115	474	1395.
11/12/96 12:57:39 UNIT 182	00	2151.	168.F	175.F	946.F	53.	-0.4	15.9	125.	10.	13.1	51.8	0.596	2.27	115	487	1395.
11/12/96 13:00:00 UNIT 182	100	2167.	168.F	175.F	949.F	53.	-0.4	16.1	125.	10.	13.1	52.0	0.596	2.30	115	493	1395.
/12/96 13:30:00 UNIT 182	00	2201.	170.F	177.F	947.F	53.	-0.4	16.1	124.	13.	13.0	52.5	0.595	2.32	115	564	1396.
11/12/96 14:00:00 UNIT 182	100	2200.	170.F	177.F	946.F	53.	-0.4	16.1	125.	13.	13.1	53.1	0.594	2.31	115	635	1396.
/12/96 14:30:00 UNIT 182	100	2193.	169.F	176.F	947.F	53.	-0.4	16.2	124.	12.	13.1	53.1	0.594	2.31	115	706	1397.
11/12/96 15:00:00 UNIT 182	00	2194.	169.F	177.F	947.F	53.	-0.4	16.1	124.	12.	13.0	54.0	0.592	2.31	115	777	1397.
/12/96 15:30:00 UNIT 182	100	2179.	169.F	176.F	947.F	53.	-0.4	16.1	124.	12.	13.1	53.4	0.593	2.30	115	848	1398.
/12/96 16:00:00 UNIT 182	0	2214.	169.F	177.F	945.F	53.	-0.4	16.1	124.	12.	13.1	54.4	0.591	2.31	115	919	1398.
11/12/96 17:00:00 UNIT 182	100	2186.	169.F	175.F	944.F	53.	-0.4	16.1	124.	12.	13.2	53.3	0.593	2.32	116	60	1399.

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARD.	BYP..	WELL FLOW	BATTERY	DUTY	PERCENT	AUXILIARY			HOURS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.4	[illegible]	[illegible]	12.	[illegible]	51.5	0.593	2.30	[illegible]	201	1400.
[illegible] 100	2205.	[illegible]	.73.F	945.F	53.	-0.4	16.?	124.	12.	13.2	52.6	0.595	2.29	116	342	1401.
/12/96 19:18:02 UNIT 182 100	2215.	168.F	174.F	943.F	53.	-0.4	16.2	124.	12.	13.3	54.1	0.592	2.29	116	385	1402.
11/12/96 19:18:10 UNIT 182 0	2221.	168.F	174.F	943.F	53.	-0.4	16.2	124.	12.	13.2	53.6	0.593	2.29	116	385	1402.
/12/96 20:00:00 UNIT 182 100	2205.	168.F	173.F	945.F	53.	-0.4	16.2	124.	12.	13.2	54.4	0.591	2.29	116	483	1402.
/12/96 21:00:00 UNIT 182 0	2218.	168.F	172.F	945.F	53.	-0.4	16.1	124.	12.	13.2	52.8	0.594	2.28	116	623	1403.
11/12/96 22:00:00 UNIT 182 100	2206.	168.F	171.F	946.F	53.	-0.4	16.2	124.	12.	13.3	52.9	0.594	2.30	116	764	1404.
/12/96 23:00:00 UNIT 182 00	2205.	167.F	171.F	943.F	53.	-0.4	16.0	123.	12.	13.3	51.9	0.596	2.27	116	903	1405.
11/13/96 00:00:00 UNIT 182 0	2189.	168.F	170.F	942.F	53.	-0.4	16.0	123.	12.	13.3	52.7	0.595	2.28	117	42	1406.
/13/96 01:00:00 UNIT 182 100	2187.	167.F	170.F	943.F	53.	-0.4	16.0	123.	12.	13.3	53.9	0.592	2.27	117	181	1407.
11/13/96 02:00:00 UNIT 182 0	2190.	167.F	169.F	944.F	53.	-0.4	16.1	123.	12.	13.2	52.4	0.595	2.26	117	320	1408.
11/13/96 03:00:00 UNIT 182 100	2184.	167.F	170.F	944.F	53.	-0.4	16.0	124.	12.	13.3	51.5	0.597	2.27	117	459	1409.
/13/96 04:00:00 UNIT 182 0	2178.	168.F	171.F	942.F	53.	-0.4	16.1	123.	12.	13.2	54.0	0.592	2.27	117	597	1410.
11/13/96 05:00:00 UNIT 182 0	2173.	168.F	171.F	942.F	53.	-0.4	16.1	123.	12.	13.3	52.4	0.595	2.27	117	735	1411.

↑

730 Am 11-13-96

/13/96 05:26:56 UNIT 182																
0	2164.	168.F	171.F	941.F	53.	-0.4	16.0	124.	12.	13.3	54.2	0.592	2.27	117	798	1412.
11/13/96 05:27:18 UNIT 182																
100	2163.	168.F	171.F	941.F	53.	-0.4	16.0	123.	13.	13.3	54.6	0.591	2.25	117	798	1412.
/13/96 05:44:44 UNIT 182																
0	2184.	169.F	171.F	943.F	53.	-0.4	16.0	123.	13.	13.3	52.9	0.594	2.27	117	839	1412.
11/13/96 05:47:10 UNIT 182																
0	2158.	168.F	171.F	941.F	53.	-0.4	16.0	123.	13.	13.3	52.7	0.595	2.27	117	844	1412.
/13/96 06:00:00 UNIT 182																
100	2165.	168.F	171.F	943.F	53.	-0.4	16.0	124.	13.	13.2	52.5	0.595	2.24	117	874	1412.
/13/96 06:30:00 UNIT 182																
00	2171.	168.F	171.F	945.F	53.	-0.4	16.1	124.	13.	13.3	53.0	0.594	2.25	117	943	1413.
11/13/96 07:00:00 UNIT 182																
100	2169.	168.F	172.F	941.F	53.	-0.4	16.0	124.	13.	13.1	53.5	0.593	2.17	118	12	1413.
/13/96 07:30:00 UNIT 182																
00	2161.	168.F	174.F	961.F	53.	-0.4	17.0	129.	13.	13.1	53.0	0.594	2.28	118	81	1414.
11/13/96 08:00:00 UNIT 182																
0	2171.	168.F	175.F	966.F	53.	-0.4	17.4	132.	13.	13.1	52.7	0.595	2.34	118	153	1414.
/13/96 08:30:00 UNIT 182																
100	2175.	169.F	176.F	967.F	53.	-0.4	17.4	131.	13.	13.0	53.7	0.593	2.33	118	225	1415.
11/13/96 09:00:00 UNIT 182																
0	2200.	169.F	177.F	969.F	53.	-0.4	17.7	132.	13.	13.0	56.2	0.588	2.39	118	298	1415.
/13/96 09:30:00 UNIT 182																
100	2182.	169.F	177.F	970.F	53.	-0.4	17.7	133.	13.	13.1	54.6	0.591	2.37	118	371	1416.
/13/96 10:00:00 UNIT 182																
0	2182.	170.F	178.F	972.F	53.	-0.4	17.8	134.	13.	13.1	53.9	0.592	2.39	118	444	1416.
11/13/96 11:00:00 UNIT 182																
100	2189.	169.F	178.F	977.F	53.	-0.4	18.2	135.	12.	13.1	55.2	0.590	2.41	118	593	1417.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-	VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS-	UNITS	ENGINE HOURS
/13/96 11:08:15 UNIT 182																
0	2185.	171.F	177.F	977.F	53.	-0.4	18.2	135.	12.	13.1	53.8	0.592	2.43	118	613	1418.
11/13/96 11:0[illegible] UNIT 18[illegible]																

100 2190. 171.F 178.F 978.F 53. -0.4 18.1 135. 12. 13.2 54.9 0.590 2.44 118 615 1418.
11/13/96 12:00:00 UNIT 182
100 2173. 173.F 180.F 978.F 53. -0.4 18.2 136. 12. 13.0 53.7 0.593 2.44 118 742 1418.
11/13/96 13:00:00 UNIT 182
100 2218. 170.F 180.F 924.F 53. -0.5 15.2 121. 13. 13.0 58.0 0.584 2.43 118 892 1419.
11/13/96 14:00:00 UNIT 182
100 2192. 171.F 180.F 921.F 52. -0.4 15.0 120. 13. 13.1 56.6 0.587 2.44 119 41 1420.
11/13/96 14:52:39 UNIT 182
100 2209. 170.F 179.F 923.F 53. -0.4 15.0 119. 12. 13.1 56.2 0.588 2.43 119 171 1421.
11/13/96 15:00:00 UNIT 182
100 2217. 170.F 179.F 922.F 53. -0.4 15.0 120. 12. 13.1 56.8 0.586 2.41 119 189 1421.
11/13/96 16:00:00 UNIT 182
100 2211. 169.F 177.F 920.F 53. -0.4 14.8 119. 12. 13.1 56.5 0.587 2.40 119 336 1422.
11/13/96 16:20:20 UNIT 182
100 2217. 169.F 176.F 919.F 55. -0.5 14.7 119. 12. 13.1 56.9 0.586 2.38 119 385 1423.
11/13/96 16:20:31 UNIT 182
100 2202. 169.F 176.F 919.F 55. -0.5 14.7 119. 12. 13.1 57.2 0.586 2.39 119 386 1423.
11/13/96 17:00:00 UNIT 182
100 2166. 168.F 174.F 905.F 55. -0.5 13.8 116. 12. 13.0 56.1 0.588 2.33 119 484 1423.
11/13/96 18:00:00 UNIT 182
100 2166. 167.F 173.F 909.F 53. -0.4 14.0 117. 12. 13.2 54.7 0.591 2.31 119 626 1424.
11/13/96 19:00:00 UNIT 182
100 2161. 168.F 172.F 910.F 53. -0.4 14.1 117. 12. 13.3 54.6 0.591 2.30 119 767 1425.
11/13/96 20:00:00 UNIT 182
100 2143. 167.F 172.F 911.F 53. -0.4 14.0 117. 12. 13.3 54.1 0.592 2.28 119 908 1426.
11/13/96 20:16:14 UNIT 182
100 2148. 167.F 171.F 911.F 53. -0.4 14.1 117. 12. 13.4 56.6 0.587 2.29 119 946 1427.
11/13/96 20:16:26 UNIT 182
100 2154. 167.F 171.F 911.F 53. -0.4 14.1 117. 12. 13.3 54.5 0.591 2.29 119 947 1427.
11/13/96 21:00:00 UNIT 182
100 2163. 167.F 171.F 912.F 53. -0.4 14.1 117. 12. 13.5 55.4 0.589 2.29 120 49 1427.
11/13/96 22:00:00 UNIT 182
100 2161. 167.F 170.F 911.F 53. -0.4 14.1 117. 12. 13.5 55.7 0.589 2.29 120 189 1428.
11/13/96 23:00:00 UNIT 182
100 2178. 167.F 170.F 911.F 53. -0.4 14.1 117. 11. 13.5 52.5 0.595 2.29 120 329 1429.
11/14/96 00:00:00 UNIT 182
100 2159. 167.F 170.F 912.F 53. -0.4 14.1 117. 11. 13.6 53.2 0.594 2.27 120 469 1430.
11/14/96 01:00:00 UNIT 182
100 2167. 167.F 170.F 911.F 53. -0.4 14.2 117. 11. 13.6 53.8 0.592 2.27 120 608 1431.
11/14/96 02:00:00 UNIT 182
100 2168. 167.F 169.F 914.F 53. -0.4 14.2 116. 11. 13.6 54.1 0.592 2.26 120 747 1432.
11/14/96 03:00:00 UNIT 182
100 2167. 167.F 169.F 912.F 53. -0.4 14.2 117. 11. 13.6 53.7 0.593 2.28 120 886 1433.
11/14/96 04:00:00 UNIT 182
100 2179. 167.F 169.F 915.F 53. -0.4 14.5 118. 10. 13.6 52.9 0.594 2.28 121 25 1434.
11/14/96 05:00:00 UNIT 182
100 2170. 168.F 170.F 915.F 53. -0.4 14.5 117. 11. 13.6 54.0 0.592 2.28 121 165 1435.
11/14/96 05:22:17 UNIT 182
100 2172. 167.F 169.F 919.F 53. -0.4 14.6 118. 11. 13.6 53.5 0.593 2.29 121 216 1436.
11/14/96 05:22:24 UNIT 182
100 2172. 167.F 169.F 919.F 53. -0.4 14.6 118. 11. 13.6 53.7 0.593 2.27 121 217 1436.
11/14/96 06:00:00 UNIT 182
100 2171. 167.F 170.F 917.F 53. -0.4 14.6 118. 11. 13.5 52.8 0.594 2.28 121 304 1436.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

ENGINE RPM | TEMPERATURE COOLANT OIL EXHAUST | OIL PSI | POSITIONS CARB. BYPASS | WELL FLOW CFM-VAC.H2O | BATTERY VOLTS | DUTY CYCLE | PERCENT OXYGEN | AUXILIARY FUEL CFM THOUSANDS-UNITS | ENGINE HOURS

11/14/96 07:00:00 UNIT 182
100 2165. 168.F 171.F 918.F 53. -0.4 14.7 119. 11. 13.4 53.2 0.594 2.33 121 444 1437.
11/14/96 08:00:00 UNIT 182

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100  [illegible]  167.F  17[illegible].F  92[illegible].F  53.  -0.4  15.1  120.  [illegible]
11/14/96 08:33:19  UNIT 182
00  2218.  16[illegible].F  [illegible]  53.
                                       119.  1[illegible].  1[illegible]  [illegible]  0.[illegible]  2.64  121  672  1439.
                  175.F  917.F  53.  -0.4  15.0  120.  12.  13.4  52.1  0.596  2.66  121  673  1439.
11/14/96 08:36:11  UNIT 182
00  2204.  168.F  175.F  917.F  53.  -0.4  15.0  119.  12.  13.5  52.1  0.596  2.64  121  674  1439.
1/14/96 09:00:00  UNIT 182
100  2208.  169.F  176.F  914.F  53.  -0.4  14.9  119.  12.  13.4  54.2  0.592  2.62  121  737  1439.
11/14/96 09:15:32  UNIT 182
00  2156.  167.F  176.F  931.F  53.  -0.4  16.3  124.  11.  13.3  52.2  0.596  2.64  121  779  1440.
11/14/96 09:33:04  UNIT 182
100  2197.  170.F  177.F  912.F  53.  -0.4  14.9  119.  12.  13.3  54.3  0.591  2.54  121  824  1440.
1/14/96 09:40:10  UNIT 182
00  2194.  168.F  177.F  911.F  53.  -0.4  15.0  119.  12.  13.4  56.2  0.588  2.50  121  843  1440.
11/14/96 10:00:00  UNIT 182
100  2217.  170.F  178.F  915.F  52.  -0.4  15.0  119.  12.  13.3  56.5  0.587  2.68  121  895  1440.
1/14/96 11:00:00  UNIT 182
00  2188.  170.F  178.F  915.F  52.  -0.4  15.0  119.  11.  13.3  54.9  0.590  2.67  122  57  1441.
11/14/96 11:53:12  UNIT 182
00  2201.  171.F  180.F  918.F  52.  -0.4  15.3  120.  11.  13.3  56.8  0.586  2.68  122  202  1442.
/14/96 12:00:00  UNIT 182
100  2197.  172.F  181.F  916.F  52.  -0.4  15.2  120.  11.  13.2  58.2  0.584  2.58  122  220  1442.
/14/96 12:11:17  UNIT 182
00  2201.  171.F  180.F  919.F  52.  -0.4  15.2  120.  11.  13.3  54.9  0.590  2.68  122  250  1443.  14:11s
11/14/96 12:11:26  UNIT 182
100  2210.  171.F  180.F  919.F  52.  -0.4  15.2  120.  11.  13.3  55.4  0.589  2.65  122  250  1443.
/14/96 12:11:33  UNIT 182
0  2200.  171.F  180.F  919.F  52.  -0.4  15.2  120.  11.  13.3  54.5  0.591  2.67  122  251  1443.
11/14/96 12:12:41  UNIT 182
0  2206.  171.F  180.F  918.F  52.  -0.4  15.3  120.  11.  13.3  55.5  0.589  2.65  122  254  1443.
/14/96 12:13:11  UNIT 182
100  2198.  171.F  180.F  918.F  52.  -0.4  15.2  120.  11.  13.3  56.9  0.586  2.65  122  255  1443.
1/14/96 13:00:00  UNIT 182
0  2191.  171.F  181.F  919.F  52.  -0.4  15.3  120.  11.  13.2  58.1  0.584  2.62  122  380  1443.
1/14/96 13:41:02  UNIT 182
100  2205.  171.F  181.F  919.F  52.  -0.4  15.2  120.  10.  13.3  56.4  0.587  2.61  122  489  1444.  Remove Hose To ADjust
/14/96 14:00:00  UNIT 182
0  2197.  171.F  179.F  920.F  52.  -0.5  15.2  120.  10.  13.2  56.2  0.588  2.60  122  540  1444.  [illegible]
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11/14/96 14:15:36 UNIT 182	0	2175.	170.F	179.F	917.F	52.	-0.4	15.1	119.	10.	13.4	56.9	0.586	2.51	122	581	1445.
/14/96 15:00:00 UNIT 182	100	2182.	170.F	177.F	918.F	52.	-0.4	15.0	119.	9.	13.3	57.7	0.585	2.56	122	697	1445.
/14/96 16:00:00 UNIT 182	0	2180.	170.F	178.F	918.F	52.	-0.4	15.1	119.	10.	13.3	57.7	0.585	2.57	122	853	1446.
11/14/96 17:00:00 UNIT 182	100	2202.	169.F	177.F	918.F	52.	-0.4	15.0	119.	10.	13.3	56.1	0.588	2.55	123	9	1447.
/14/96 18:00:00 UNIT 182	0	2195.	169.F	176.F	919.F	52.	-0.4	15.0	119.	10.	13.3	57.0	0.586	2.52	123	164	1448.
11/14/96 18:45:39 UNIT 182	0	2205.	168.F	176.F	919.F	52.	-0.4	15.0	119.	10.	13.5	57.6	0.585	2.53	123	281	1449.

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	UNITS	ENGINE HOURS
/14/96 19:00:00 UNIT 182 · 0	2193.	169.F	175.F	919.F	53.	-0.4	15.0	119.	10.	13.0	57.1	0.586	2.53	123	318	1449.
11/14/96 20:00:00 UNIT 182 · 0	2207.	168.F	174.F	919.F	52.	-0.4	15.1	119.	10.	13.5	54.2	0.592	2.50	123	471	1450.
/14/96 21:00:00 UNIT 182 · 100	2188.	168.F	173.F	918.F	52.	-0.4	15.1	119.	10.	13.5	56.5	0.587	2.49	123	624	1451.
/14/96 22:00:00 UNIT 182 · 0	2192.	168.F	173.F	920.F	52.	-0.3	15.1	119.	9.	13.5	55.4	0.589	2.51	123	776	1452.
11/14/96 23:00:00 UNIT 182 · 100	2193.	167.F	172.F	921.F	52.	-2.1	15.9	122.	9.	13.6	55.1	0.590	2.47	123	927	1453.
/15/96 00:00:00 UNIT 182 · 0	2202.	167.F	172.F	921.F	53.	-2.2	15.9	122.	9.	13.6	53.2	0.594	2.49	124	78	1454.
11/15/96 01:00:00 UNIT 182 · 0	2194.	168.F	172.F	920.F	53.	-2.2	15.9	122.	9.	13.6	53.5	0.593	2.47	124	229	1455.
/15/96 02:00:00 UNIT 182 · 100	2195.	168.F	172.F	919.F	53.	-2.2	15.9	123.	9.	13.6	54.9	0.590	2.47	124	380	1456.
/15/96 03:00:00 UNIT 182 · 0	2195.	168.F	173.F	919.F	53.	-2.2	15.9	122.	8.	13.6	55.5	0.589	2.49	124	531	1457.
/15/96 04:00:00 UNIT 182 · 100	2213.	167.F	171.F	920.F	53.	-2.2	15.9	123.	8.	13.6	54.9	0.590	2.45	124	682	1458.
/15/96 05:00:00 UNIT 182 · 0	2192.	167.F	171.F	920.F	53.	-2.2	15.9	123.	8.	13.6	53.6	0.593	2.44	124	832	1459.
11/15/96 05:38:41 UNIT 182 · 0	2196.	167.F	172.F	920.F	53.	-2.2	15.9	122.	8.	13.7	54.1	0.592	2.45	124	929	1460.
/15/96 05:38:51 UNIT 182 · 100	2195.	167.F	172.F	920.F	53.	-2.2	15.9	123.	8.	13.7	52.4	0.595	2.47	124	929	1460.
11/15/96 05:38:59 UNIT 182 · 0	2194.	167.F	172.F	920.F	53.	-2.2	15.9	123.	8.	13.7	53.0	0.594	2.47	124	930	1460.

0742
11.15.9

11/15/96 06:00:00 UNIT 182	100	2203.	168.F	171.F	920.F	53.	-2.2	15.9	123.	8.	13.6	54.6	0.591	2.44	124	982	1460.
11/15/96 07:00:00 UNIT 182	100	2190.	169.F	173.F	917.F	52.	-2.3	15.8	122.	9.	13.6	55.7	0.589	2.47	125	132	1461.
11/15/96 08:00:00 UNIT 182	100	2175.	170.F	176.F	916.F	52.	-2.3	15.8	122.	9.	13.4	55.4	0.589	2.46	125	283	1462.
11/15/96 09:00:00 UNIT 182	100	2165.	169.F	176.F	916.F	52.	-2.3	15.8	122.	9.	13.4	54.8	0.590	2.46	125	434	1463.
11/15/96 09:41:47 UNIT 182	100	2167.	170.F	177.F	915.F	52.	-2.3	15.8	122.	8.	13.4	56.5	0.587	2.50	125	540	1464.
11/15/96 10:00:00 UNIT 182	100	2153.	168.F	176.F	915.F	52.	-2.2	15.8	122.	8.	13.5	56.3	0.587	2.48	125	586	1464.
11/15/96 11:00:00 UNIT 182	100	2189.	169.F	175.F	922.F	52.	-2.2	16.0	123.	7.	13.5	54.4	0.571	2.50	125	730	[illegible]
11/15/96 11:12:25 UNIT 182	100	2170.	169.F	175.F	923.F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-2.2	16.0	[illegible]	7.	13.5	54.7	0.591	[illegible]	[illegible]	891	1466.
11/15/96 13:00:00 UNIT 182	100	2183.	169.F	175.F	922.F	53.	-2.2	16.0	124.	7.	13.4	54.0	0.592	2.50	126	43	1467.
11/15/96 14:00:00 UNIT 182	100	2185.	170.F	176.F	921.F	53.	-2.2	16.0	124.	7.	13.4	54.1	0.592	2.51	126	196	1468.
11/15/96 15:00:00 UNIT 182	100	2191.	169.F	177.F	922.F	52.	-2.2	16.0	124.	7.	13.4	54.6	0.591	2.55	126	350	1469.
11/15/96 16:00:00 UNIT 182	100	2190.	168.F	174.F	923.F	53.	-2.2	16.0	124.	7.	13.5	53.4	0.593	2.50	126	503	1470.
11/15/96 17:00:00 UNIT 182	100	2197.	168.F	175.F	923.F	53.	-2.2	16.0	124.	7.	13.4	53.3	0.593	2.51	126	656	1471.

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

	ENGINE	TEMPERATURE			OIL	POSITIONS		WELL FLOW		BATTERY	DUTY	PERCENT	AUXILIARY FUEL			ENGINE
	RPM	COOLANT	OIL	EXHAUST	PSI	CARB.	BYPASS	CFM	VAC.H2O	VOLTS	CYCLE	OXYGEN	CFM	THOUSANDS-UNITS		HOURS
11/15/96 18:00:00 UNIT 182 100	2201.	169.F	174.F	923.F	53.	-2.2	16.1	124.	7.	13.5	55.3	0.589	2.50	126	809	1472.
11/15/96 18:10:23 UNIT 182 100	2181.	169.F	175.F	923.F	54.	-2.3	16.0	123.	7.	13.0	56.5	0.587	2.51	126	835	1473.
11/15/96 18:10:30 UNIT 182 100	2176.	169.F	175.F	923.F	55.	-2.3	16.0	123.	7.	13.1	56.9	0.586	2.50	126	836	1473.
11/15/96 19:00:00 UNIT 182 100	2184.	168.F	175.F	924.F	53.	-2.2	16.0	123.	7.	13.3	55.5	0.589	2.50	126	962	1473.
11/15/96 20:00:00 UNIT 182 100	2168.	168.F	174.F	924.F	53.	-2.2	16.1	124.	7.	13.3	54.7	0.591	2.48	127	114	1474.
11/15/96 21:00:00 UNIT 182 100	2192.	169.F	175.F	924.F	53.	-2.2	16.0	124.	7.	13.3	56.1	0.588	2.51	127	266	1475.
11/15/96 22:00:00 UNIT 182 100	2192.	169.F	175.F	924.F	53.	-2.2	16.0	124.	7.	13.2	56.0	0.588	2.51	127	419	1476.
11/15/96 23:00:00 UNIT 182 100	2169.	169.F	175.F	923.F	53.	-2.2	16.0	123.	7.	13.2	55.9	0.588	2.49	127	571	1477.
11/16/96 00:00:00 UNIT 182 100	2168.	168.F	175.F	922.F	53.	-2.2	16.1	123.	7.	13.3	55.4	0.589	2.51	127	724	1478.

11/16/96 01:00:00 UNIT 182																
100	2170.	169.F	175.F	923.F	53.	-2.2	16.1	123.	7.	13.3	55.1	0.590	2.49	127	876	1479.
11/16/96 02:00:00 UNIT 182																
100	2167.	168.F	175.F	924.F	53.	-2.2	16.0	123.	6.	13.3	55.2	0.590	2.48	128	29	1480.
11/16/96 03:00:00 UNIT 182																
100	2156.	169.F	175.F	923.F	53.	-2.2	16.0	123.	6.	13.2	55.4	0.589	2.48	128	181	1481.
11/16/96 04:00:00 UNIT 182																
100	2178.	168.F	175.F	923.F	53.	-2.2	16.0	124.	7.	13.3	55.8	0.588	2.50	128	333	1482.
11/16/96 05:00:00 UNIT 182																
100	2163.	168.F	174.F	922.F	53.	-2.2	16.1	124.	6.	13.3	55.6	0.589	2.47	128	484	1483.
11/16/96 05:38:43 UNIT 182																
100	2176.	168.F	175.F	923.F	53.	-2.2	16.0	123.	6.	13.3	56.8	0.586	2.45	128	582	1484.
11/16/96 05:38:50 UNIT 182																
100	2160.	168.F	175.F	923.F	53.	-2.2	16.0	123.	6.	13.3	56.3	0.587	2.47	128	582	1484.
11/16/96 06:00:00 UNIT 182																
100	2169.	168.F	175.F	923.F	53.	-2.2	16.1	123.	6.	13.3	56.8	0.586	2.48	128	636	1484.
11/16/96 07:00:00 UNIT 182																
100	2164.	169.F	176.F	921.F	53.	-2.2	16.0	124.	7.	13.2	55.3	0.589	2.47	128	788	1485.
11/16/96 08:00:00 UNIT 182																
100	2156.	169.F	177.F	923.F	53.	-2.2	16.1	124.	7.	13.2	56.7	0.587	2.52	128	940	1486.
11/16/96 09:00:00 UNIT 182																
100	2143.	169.F	178.F	926.F	53.	-1.8	16.4	125.	7.	13.2	57.3	0.585	2.55	129	94	1487.
11/16/96 10:00:00 UNIT 182																
100	2163.	170.F	179.F	926.F	53.	-2.2	16.3	125.	6.	13.0	56.4	0.587	2.56	129	250	1488.
11/16/96 11:00:00 UNIT 182																
100	2161.	172.F	182.F	931.F	52.	-2.2	16.7	126.	6.	13.0	58.1	0.584	2.63	129	407	1489.
11/16/96 11:38:19 UNIT 182																
100	2166.	175.F	183.F	930.F	52.	-2.4	16.1	127.	5.	13.0	58.1	0.584	2.63	129	508	1490.
11/16/96 11:38:26 UNIT 182																
100	2170.	175.F	183.F	930.F	52.	-2.4	16.0	126.	5.	13.1	59.1	0.582	2.63	129	509	1490.
11/16/96 12:00:00 UNIT 182																
100	2156.	173.F	182.F	932.F	52.	-2.4	16.5	126.	5.	13.0	56.6	0.587	2.62	129	566	1490.
11/16/96 13:00:00 UNIT 182																
100	2163.	172.F	182.F	932.F	52.	-2.4	16.5	127.	5.	13.1	58.5	0.583	2.59	129	725	1491.
11/16/96 14:00:00 UNIT 182																
100	2168.	173.F	183.F	931.F	52.	-2.4	16.5	126.	6.	13.1	58.2	0.584	2.62	129	884	1492.
11/16/96 15:00:00 UNIT 182																
100	2165.	172.F	181.F	930.F	52.	-2.3	16.5	127.	6.	13.1	59.6	0.581	2.59	130	42	1493.

V.R.SYSTEMS INC.　　MODEL V3 S/N 182

PERMIT NO.

ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O		BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS-UNITS		ENGINE HOURS	
11/16/96 16:00:00 UNIT 182																
100	2172.	171.F	180.F	932.F	52.	-2.3	16.5	127.	6.	13.1	59.1	0.582	2.56	130	200	1494.
11/16/96 17:00:00 UNIT 182																
100	2175.	170.F	179.F	934.F	53.	-2.2	16.5	127.	6.	13.2	58.1	0.584	2.56	130	356	1495.
11/16/96 17:28:28 UNIT 182																
100	2170.	169.F	178.F	935.F	53.	-2.2	16.6	127.	6.	13.2	57.1	0.586	2.56	130	430	1496.
11/16/96 17:28:33 UNIT 182																
100	2162.	169.F	178.F	935.F	53.	-2.2	16.6	127.	6.	13.3	58.3	0.583	2.55	130	431	1496.
11/16/96 17:28:45 UNIT 182																
[illegible]																

11/16/96 17:30:12 UNIT 182																	
	0	2162.	170.F	178.F	935.F	53.	-2.2	16.6	127.	6.	13.2	59.2	0.582	2.57	130	435	1496.
/16/96 17:30:23 UNIT 182																	
	100	2166.	170.F	178.F	935.F	53.	-2.2	16.6	127.	6.	13.2	58.0	0.584	2.56	130	435	1496.
/16/96 18:00:00 UNIT 182																	
	0	2171.	169.F	178.F	936.F	54.	-2.3	16.5	127.	6.	13.1	58.4	0.583	2.56	130	513	1496.
11/16/96 19:00:00 UNIT 182																	
	100	2161.	168.F	177.F	935.F	52.	-2.2	16.6	127.	7.	13.2	57.6	0.585	2.55	130	669	1497.
/16/96 20:00:00 UNIT 182																	
	0	2170.	169.F	177.F	936.F	52.	-2.2	16.6	127.	7.	13.1	58.1	0.584	2.55	130	824	1498.
11/16/96 21:00:00 UNIT 182																	
	0	2164.	169.F	178.F	935.F	53.	-2.2	16.7	127.	7.	13.2	57.8	0.584	2.55	130	980	1499.
/16/96 22:00:00 UNIT 182																	
	100	2157.	169.F	178.F	935.F	53.	-2.2	16.7	127.	8.	13.3	58.0	0.584	2.53	131	135	1500.
/16/96 23:00:00 UNIT 182																	
	0	2175.	169.F	177.F	933.F	53.	-2.2	16.7	127.	8.	13.2	58.8	0.582	2.53	131	290	1501.
11/17/96 00:00:00 UNIT 182																	
	100	2174.	169.F	176.F	934.F	53.	-2.2	16.7	128.	8.	13.2	58.1	0.584	2.53	131	444	1502.
/17/96 01:00:00 UNIT 182																	
	[illegible]	[illegible]	[illegible]	176.F	934.F	53.	[illegible]	[illegible]	[illegible]	8.	[illegible]	[illegible]	0.584	2.53	131	[illegible]	1503.
11/17/96 02:00:00 UNIT 182																	
	0	2191.	169.F	176.F	936.F	53.	-2.1	16.8	127.	8.	13.3	56.2	0.588	2.51	131	752	1504.
/17/96 03:00:00 UNIT 182																	
	100	2192.	169.F	176.F	936.F	53.	-1.6	16.8	128.	8.	13.3	58.3	0.583	2.51	131	906	1505.
11/17/96 04:00:00 UNIT 182																	
	0	2187.	168.F	175.F	939.F	53.	-1.5	16.8	128.	8.	13.2	57.1	0.586	2.51	132	60	1506.
/17/96 05:00:00 UNIT 182																	
	100	2177.	169.F	176.F	936.F	53.	-1.5	16.8	128.	9.	13.2	56.2	0.588	2.51	132	214	1507.
/17/96 05:39:20 UNIT 182																	
	0	2182.	169.F	176.F	938.F	53.	-1.6	16.8	128.	9.	13.3	57.0	0.586	2.51	132	315	1508.
11/17/96 05:39:27 UNIT 182																	
	100	2193.	169.F	176.F	937.F	53.	-1.6	16.8	128.	9.	13.3	57.8	0.584	2.51	132	315	1508.
/17/96 06:00:00 UNIT 182																	
	100	2193.	168.F	175.F	939.F	53.	-1.6	16.8	128.	9.	13.3	57.2	0.586	2.51	132	368	1508.
11/17/96 07:00:00 UNIT 182																	
	00	2187.	169.F	177.F	935.F	53.	-1.6	16.8	128.	9.	13.2	56.6	0.587	2.50	132	521	1509.
/17/96 08:00:00 UNIT 182																	
	100	2202.	167.F	170.F	931.F	53.	-2.3	16.6	126.	9.	13.5	54.0	0.592	2.44	132	674	
/17/96 09:00:00 UNIT 182																	
	[illegible]	2201.	167.F	170.F	[illegible]			[illegible]									
											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	971	1512.
	[illegible]	[illegible]	[illegible]	173.F	925.F	53.	-2.3	16.3	126.	9.	13.5	53.9	0.592	2.44	133	120	1513.
11/17/96 12:00:00 UNIT 182																	
	0	2197.	169.F	174.F	926.F	53.	-2.3	16.3	125.	9.	13.4	55.2	0.590	2.46	133	270	1514.

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

		ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	-UNITS	ENGINE HOURS
/17/96 12:07:35 UNIT 182																	
	100	2195.	169.F	173.F	927.F	53.	-2.3	16.3	125.	9.	13.4	55.0	0.590	2.45	133	289	1515.
11/17/96 13:00:00 UNIT 182																	
	0	2202.	168.F	173.F	928.F	53.	-2.3	16.3	125.	8.	13.4	53.7	0.593	2.43	133	420	1515.
/17/96 14:00:00 UNIT 182																	
	100	2209.	168.F	172.F	927.F	53.	-2.3	16.3	125.	8.	13.5	54.5	0.591	2.44	133	569	1516.
/17/96 15:00:00 UNIT 182																	
	0	2207.	167.F	171.F	925.F	53.	-2.3	16.2	125.	9.	13.4	55.0	0.590	2.44	133	718	1517.
11/17/96 16:00:00 UNIT 182																	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

11/17/96 17:00:00 UNIT 182	0	2216.	167.F	171.F	925.F	53.	-2.3	16.1	125.	9.	13.4	55.0	0.590	2.44	134	16	1519.
/17/96 18:00:00 UNIT 182	100	2200.	167.F	170.F	926.F	53.	-2.3	16.1	124.	9.	13.4	54.6	0.591	2.42	134	165	1520.
/17/96 18:15:40 UNIT 182	0	2199.	167.F	170.F	926.F	53.	-2.3	16.1	124.	9.	13.5	53.8	0.592	2.42	134	203	1521.
11/17/96 19:00:00 UNIT 182	100	2209.	166.F	170.F	925.F	53.	-2.3	16.1	124.	9.	13.5	55.5	0.589	2.42	134	313	1521.
/17/96 20:00:00 UNIT 182	0	2204.	167.F	169.F	925.F	53.	-2.3	16.1	124.	9.	13.4	53.6	0.593	2.41	134	461	1522.
11/17/96 21:00:00 UNIT 182	0	2205.	167.F	169.F	925.F	53.	-2.3	16.1	124.	9.	13.5	54.3	0.591	2.41	134	608	1523.
/17/96 22:00:00 UNIT 182	100	2196.	167.F	170.F	926.F	53.	-2.3	16.1	124.	9.	13.4	53.5	0.593	2.41	134	755	1524.
/17/96 23:00:00 UNIT 182	0	2195.	166.F	169.F	926.F	53.	-2.3	16.1	124.	9.	13.5	54.3	0.591	2.42	134	903	1525.
/18/96 00:00:00 UNIT 182	100	2198.	166.F	169.F	926.F	53.	-2.3	16.1	124.	9.	13.4	54.3	0.591	2.41	135	51	1526.
/18/96 01:00:00 UNIT 182	0	2198.	167.F	169.F	925.F	53.	-2.3	16.1	124.	9.	13.5	53.7	0.593	2.41	135	198	1527.
11/18/96 02:00:00 UNIT 182	0	2193.	167.F	169.F	924.F	53.	-2.3	16.1	124.	9.	13.4	53.8	0.592	2.40	135	346	1528.
/18/96 03:00:00 UNIT 182	0	2208.	167.F	169.F	925.F	53.	-2.3	16.1	124.	9.	13.4	54.9	0.590	2.42	135	493	1529.
11/18/96 04:00:00 UNIT 182	0	2188.	167.F	170.F	926.F	53.	-2.3	16.0	123.	9.	13.5	52.6	0.595	2.42	135	641	1530.
/18/96 05:00:00 UNIT 182	100	2192.	167.F	170.F	925.F	53.	-2.3	16.0	124.	9.	13.4	54.8	0.590	2.41	135	788	1531.
/18/96 05:39:23 UNIT 182	0	2189.	167.F	170.F	926.F	53.	-2.3	16.0	124.	9.	13.5	52.6	0.595	2.42	135	885	1532.
11/18/96 06:00:00 UNIT 182	100	2175.	168.F	171.F	927.F	53.	-2.3	16.0	123.	9.	13.3	53.3	[illegible]	[illegible]	135	[illegible]	[illegible]
/18/96 07:00:00 UNIT 182	0	2190.	167.F	170.F	[illegible]	53.											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55.1	0.590	2.42	[illegible]	[illegible]	1534.
/18/96 09:00:00 UNIT 182	100	2175.	[illegible]	[illegible]	926.F	53.	-2.3	15.9	123.	9.	13.3	55.9	0.588	2.42	136	380	1535.
/18/96 10:00:00 UNIT 182	0	2152.	169.F	174.F	923.F	53.	-2.4	15.9	123.	9.	13.3	56.3	0.587	2.44	136	529	1536.
/18/96 11:00:00 UNIT 182	100	2146.	168.F	175.F	925.F	53.	-2.4	15.9	124.	9.	13.3	54.5	0.591	2.46	136	678	1537.
/18/96 12:00:00 UNIT 182	0	2178.	170.F	177.F	922.F	53.	-2.3	16.0	124.	8.	13.2	54.1	0.592	2.64	136	829	1538.
11/18/96 13:00:00 UNIT 182	0	2164.	170.F	178.F	921.F	53.	-2.2	15.9	124.	8.	13.3	56.2	0.588	2.68	136	991	1539.

V.R.SYSTEMS INC.

MODEL V3 S/N 182
PERMIT NO.

		ENGINE	TEMPERATURE			OIL	POSITIONS		WELL FLOW		BATTERY	DUTY	PERCENT	AUXILIARY FUEL			ENGINE
		RPM	COOLANT	OIL	EXHAUST	PSI	CARB.	BYPASS	CFM-	VAC.H2O	VOLTS	CYCLE	OXYGEN	CFM	THOUSANDS-	UNITS	HOURS
/18/96 14:00:00 UNIT 182	100	2191.	170.F	180.F	937.F	52.	-1.8	17.1	129.	8.	13.1	57.5	0.585	2.58	137	151	1540.
11/18/96 14:27:46 UNIT 182	0	2192.	170.F	179.F	940.F	52.	-1.8	17.1	129.	8.	13.3	57.2	0.586	2.58	137	224	1541.
/18/96 15:00:00 UNIT 182	100	2198.	169.F	179.F	941.F	52.	-1.9	17.1	128.	7.	13.2	57.0	0.586	2.56	137	308	1541.
/18/96 16:00:00 UNIT 182	0	2198.	168.F	177.F	940.F	52.	-2.0	17.1	128.	6.	13.2	56.5	0.587	2.55	137	464	1542.
11/18/96 17:00:00 UNIT 182	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

11/18/96 18:00:00 UNIT 182	0	2201.	169.F	176.F	942.F	52.	-2.0	17.1	128.	8.	13.2	58.3	0.583	2.53	137	773	1544.
/18/96 18:22:07 UNIT 182	100	2194.	169.F	176.F	943.F	53.	-2.2	17.0	128.	8.	13.1	58.1	0.584	2.50	137	830	1545.
/18/96 19:00:00 UNIT 182	0	2195.	168.F	175.F	939.F	52.	-2.2	16.9	128.	8.	13.3	55.9	0.588	2.49	137	926	1545.
11/18/96 20:00:00 UNIT 182	100	2197.	168.F	174.F	941.F	52.	-2.3	16.9	128.	8.	13.3	56.1	0.588	2.51	138	79	1546.
/18/96 21:00:00 UNIT 182	0	2203.	168.F	174.F	941.F	52.	-2.3	16.9	128.	7.	13.3	56.9	0.586	2.49	138	231	1547.
11/18/96 22:00:00 UNIT 182	0	2202.	168.F	174.F	941.F	52.	-2.3	16.9	128.	7.	13.4	56.1	0.588	2.49	138	384	1548.
/18/96 23:00:00 UNIT 182	100	2197.	168.F	174.F	941.F	52.	-2.3	16.9	127.	7.	13.4	56.5	0.587	2.49	138	536	1549.
/19/96 00:00:00 UNIT 182	0	2189.	167.F	173.F	942.F	52.	-2.3	16.9	127.	7.	13.3	54.7	0.591	2.48	138	688	1550.
/19/96 01:00:00 UNIT 182	100	2175.	167.F	172.F	942.F	52.	-2.3	16.9	127.	7.	13.3	54.5	0.591	2.47	138	840	1551.
/19/96 02:00:00 UNIT 182	0	2179.	167.F	173.F	942.F	52.	-2.3	16.9	127.	7.	13.4	56.3	0.587	2.48	138	992	1552.
11/19/96 03:00:00 UNIT 182	00	2180.	167.F	173.F	941.F	52.	-2.3	16.9	127.	6.	13.4	56.3	0.587	2.49	139	144	1553.
/19/96 04:00:00 UNIT 182	00	2189.	168.F	173.F	941.F	52.	-2.3	16.9	127.	6.	13.3	54.4	0.591	2.49	139	296	1554.
11/19/96 05:00:00 UNIT 182	0	2183.	168.F	175.F	940.F	52.	-2.3	16.9	127.	7.	13.4	56.7	0.587	2.50	139	448	1555.
/19/96 05:33:23 UNIT 182	100	2189.	168.F	173.F	941.F	52.	-2.3	16.9	127.	7.	13.4	55.7	0.589	2.48	139	533	1556.
/19/96 06:00:00 UNIT 182	0	2187.	168.F	173.F	942.F	52.	-2.3	16.9	127.	7.	13.3	55.1	0.590	2.50	139	600	1556.
11/19/96 07:00:00 UNIT 182	100	2183.	167.F	172.F	942.F	52.	-2.3	16.9	127.	7.	13.3	55.8	0.588	2.48	139	752	1557.
/19/96 08:00:00 UNIT 182	0	2169.	168.F	174.F	942.F	52.	-2.3	16.9	127.	7.	13.3	56.3	0.587	2.50	139	904	1558.
11/19/96 09:00:00 UNIT 182	0	2165.	169.F	175.F	937.F	52.	-2.3	16.8	127.	7.	13.2	57.0	0.586	2.50	140	56	1559.
/19/96 10:00:00 UNIT 182	100	2159.	169.F	176.F	937.F	52.	-2.3	16.8	127.	7.	13.2	56.3	0.587	2.51	140	209	1560.
/19/96 10:17:09 UNIT 182	0	2211.	168.F	177.F	943.F	52.	-2.3	17.5	130.	7.	13.2	55.0	0.590	2.81	140	253	1561.
11/19/96 11:00:00 UNIT 182	0	2213.	169.F	177.F	941.F	52.	-1.7	17.2	129.	6.	13.1	58.1	0.584	2.78	140	373	1561.
/19/96 12:00:00 UNIT 182	100	2201.	170.F	178.F	943.F	52.	-2.7	17.4	129.	6.	13.2	58.4	0.583	2.60	140	534	1562.
/19/96 13:00:00 UNIT 182	0	2199.	169.F	178.F	948.F	52.	-2.7	17.8	131.	6.	13.1	58.6	0.583	2.62	140	693	1563.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O		BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS-UNITS		ENGINE HOURS
/19/96 13:02:53 UNIT 182	100	2203.	169.F	179.F	946.F	52.	-2.7	17.8	131.	6.	13.1	58.5	0.583	2.62	140	700	1563.
/19/96 14:00:00 UNIT 182	0	2203.	170.F	179.F	974.F	52.	-1.9	18.2	133.	5.	13.2	58.0	0.584	2.62	140	853	1564.
11/19/96 15:00:00 UNIT 182	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

11/19/96 16:00:00 UNIT 182
100 2200. 169.F 178.F 953.F 52. -2.6 17.9 133. 5. 13.3 59.1 0.582 2.59 141 170 1566.
11/19/96 17:00:00 UNIT 182
100 2203. 168.F 176.F 952.F 53. -2.8 17.8 132. 5. 13.3 58.4 0.583 2.57 141 327 1567.
11/19/96 17:49:55 UNIT 182
100 2199. 169.F 175.F 952.F 52. -2.5 17.8 131. 5. 13.3 55.2 0.590 2.57 141 457 1568.
11/19/96 17:50:02 UNIT 182
100 2194. 168.F 176.F 952.F 53. -2.6 17.8 131. 5. 13.2 56.5 0.587 2.57 141 457 1568.
11/19/96 18:00:00 UNIT 182
100 2193. 168.F 176.F 953.F 53. -2.6 17.8 130. 4. 13.1 57.2 0.586 2.57 141 483 1568.
11/19/96 19:00:00 UNIT 182
100 2198. 168.F 175.F 952.F 52. -2.6 17.8 131. 5. 13.3 55.6 0.589 2.55 141 640 1569.
11/19/96 20:00:00 UNIT 182
100 2197. 168.F 175.F 952.F 53. -2.7 17.7 130. 5. 13.3 56.5 0.587 2.55 141 795 1570.
11/19/96 21:00:00 UNIT 182
100 2195. 168.F 175.F 951.F 53. -2.4 17.7 130. 5. 13.4 55.3 0.589 2.55 141 950 1571.
11/19/96 22:00:00 UNIT 182
100 2207. 168.F 174.F 951.F 53. -2.0 17.7 130. 5. 13.3 55.3 0.589 2.54 142 105 1572.
11/19/96 23:00:00 UNIT 182
100 2187. 168.F 174.F 944.F 53. -2.6 17.3 128. 5. 13.4 57.9 0.584 2.50 142 259 1573.
11/20/96 00:00:00 UNIT 182
100 2181. 168.F 174.F 945.F 53. -2.8 17.3 128. 5. 13.2 55.5 0.589 2.53 142 412 1574.
11/20/96 01:00:00 UNIT 182
100 2158. 169.F 175.F 946.F 52. -3.1 17.3 128. 5. 13.2 55.7 0.589 2.49 142 565 1575.
11/20/96 02:00:00 UNIT 182
100 2166. 168.F 175.F 944.F 53. -3.3 17.3 128. 5. 13.3 57.0 0.586 2.48 142 718 1576.
11/20/96 03:00:00 UNIT 182
100 2171. 169.F 176.F 943.F 52. -2.9 17.3 128. 5. 13.3 57.1 0.586 2.52 142 872 1577.
11/20/96 04:00:00 UNIT 182
100 2196. 170.F 178.F 952.F 52. -2.3 17.9 133. 5. 13.3 56.2 0.588 2.60 143 27 1578.
11/20/96 05:00:00 UNIT 182
100 2206. 169.F 177.F 957.F 53. -2.0 18.1 133. 5. 13.2 55.4 0.589 2.58 143 185 1579.
11/20/96 05:43:42 UNIT 182
100 2211. 168.F 175.F 981.F 53. -1.3 18.1 133. 4. 13.4 56.0 0.588 2.58 143 301 1580.

11/20/96 06:00:00 UNIT 182
100 2196. 169.F 177.F 954.F 52. -1.8 18.0 132. 5. 13.2 56.2 0.588 2.57 143 344 1580.
11/20/96 07:00:00 UNIT 182
100 2189. 169.F 178.F 950.F 53. -4.3 17.8 131. 5. 13.3 58.5 0.583 2.56 143 500 1581.
11/20/96 08:00:00 UNIT 182
100 2184. 169.F 179.F 948.F 52. -4.0 17.9 131. 6. 13.2 57.6 0.585 2.56 143 657 1582.
11/20/96 08:30:50 UNIT 182
100 2171. 170.F 179.F 947.F 52. -4.8 17.8 131. 6. 13.1 2.57
11/20/96 0[illegible]
2.58 143 739 1583.
11/20/96 08:31:39 UNIT 182
100 2166. 169.F 179.F 947.F 52. -4.7 17.8 131. 6. 13.2 59.0 0.582 2.58 143 740 1583.
11/20/96 09:00:00 UNIT 182
100 2170. 170.F 180.F 945.F 53. -4.7 17.8 131. 5. 13.2 57.3 0.585 2.57 143 814 1583.
11/20/96 10:00:00 UNIT 182
100 2176. 171.F 181.F 947.F 52. -4.7 17.8 133. 5. 13.0 58.2 0.584 2.64 143 972 1584.

V.R.SYSTEMS INC. MODEL V3 S/N 182
PERMIT NO.

ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM THOUSANDS-UNITS	ENGINE HOURS

11/20/96 10:45:18 UNIT 182
100 2266. 174.F 185.F 981.F 52. 0.1 19.7 146. 4. 13.1 58.5 0.583 2.86 144 98 1585.

11/20/96 10:[illegible] UNIT 182	100	2274.	174.F	185.F	982.F	52.	0.2	20.2	144.	2.	13.1	58.6	0.583	2.85	144	127	1585.
11/20/96 10:57:58 UNIT 182	100	2235.	174.F	185.F	970.F	52.	-1.5	19.4	142.	2.	13.0	56.6	0.587	2.30	144	134	1585.
11/20/96 11:00:00 UNIT 182	100	2224.	173.F	184.F	962.F	52.	-0.6	18.7	137.	3.	12.9	57.0	0.586	2.93	144	140	1585.
11/20/96 12:00:00 UNIT 182	100	2200.	177.F	187.F	949.F	52.	-5.2	17.7	133.	4.	12.9	61.6	0.577	2.92	144	316	1586.
11/20/96 12:51:25 UNIT 182	100	2205.	176.F	187.F	957.F	52.	-5.3	17.6	134.	4.	13.0	60.4	0.579	2.89	144	466	1587.
11/20/96 13:00:00 UNIT 182	100	2196.	176.F	188.F	957.F	52.	-5.3	17.9	135.	4.	12.9	61.4	0.577	2.86	144	491	1587.
11/20/96 14:00:00 UNIT 182	100	2197.	177.F	187.F	957.F	52.	-5.3	18.5	135.	4.	12.9	61.2	0.578	2.87	144	666	1588.
11/20/96 15:00:00 UNIT 182	100	2197.	176.F	188.F	954.F	52.	-5.3	18.2	133.	4.	12.9	62.2	0.576	2.86	144	839	1589.
11/20/96 16:00:00 UNIT 182	100	2205.	170.F	181.F	955.F	52.	-5.2	18.2	133.	4.	13.0	60.9	0.578	2.85	145	11	1590.
11/20/96 17:00:00 UNIT 182	100	2196.	170.F	180.F	956.F	52.	-3.2	17.9	132.	4.	13.2	59.6	0.581	2.80	145	181	1591.
11/20/96 17:26:17 UNIT 182	100	2189.	170.F	179.F	956.F	53.	-5.0	17.5	131.	4.	13.1	58.9	0.582	2.78	145	255	1592.
11/20/96 18:00:00 UNIT 182	100	2207.	169.F	179.F	954.F	52.	-4.8	17.9	132.	4.	13.2	58.3	0.583	2.79	145	350	1592.
11/20/96 19:00:00 UNIT 182	100	2184.	168.F	178.F	956.F	52.	-4.8	17.9	131.	4.	13.2	58.3	0.583	2.79	145	518	1593.
11/20/96 20:00:00 UNIT 182	100	2194.	168.F	178.F	955.F	52.	-4.1	17.9	131.	4.	13.3	58.8	0.582	2.77	145	686	1594.
11/20/96 21:00:00 UNIT 182	100	2198.	169.F	178.F	956.F	52.	-4.2	17.8	131.	4.	13.2	56.8	0.586	2.76	145	853	1595.
11/20/96 22:00:00 UNIT 182	100	2192.	169.F	176.F	956.F	52.	-5.0	17.8	131.	4.	13.3	58.1	0.584	2.75	146	20	1596.
11/20/96 23:00:00 UNIT 182	100	2200.	168.F	176.F	955.F	52.	-4.5	16.6	131.	4.	13.4	58.2	0.584	2.75	146	187	1597.
11/21/96 00:00:00 UNIT 182	100	2215.	169.F	177.F	956.F	52.	-2.1	16.6	130.	4.	13.3	56.0	0.588	2.78	146	353	1598.
11/21/96 01:00:00 UNIT 182	100	2200.	168.F	176.F	951.F	52.	-0.4	17.0	127.	4.	13.4	57.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11/21/96 02:00:00 UNIT 1[illegible]	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	144	690	1600.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.0	129.	4.	[illegible]	[illegible]	0.587	2.71	146	854	1601.
11/21/96 04:00:00 UNIT 182																
100	2197.	168.F	174.F	955.F	53.	-3.5	17.1	129.	4.	13.3	55.5	0.589	2.71	147	19	1602.
11/21/96 05:00:00 UNIT 182																
100	2194.	168.F	174.F	954.F	52.	-3.4	17.1	129.	4.	13.3	55.2	0.590	2.73	147	185	1603.
11/21/96 06:00:00 UNIT 182																
100	2206.	168.F	175.F	953.F	53.	-2.8	17.1	130.	5.	13.4	56.4	0.587	2.72	147	349	1604.
11/21/96 07:00:00 UNIT 182																
100	2199.	169.F	176.F	951.F	52.	-3.4	17.0	130.	5.	13.3	54.8	0.590	2.71	147	514	1605.
11/21/96 08:00:00 UNIT 182																
100	2197.	169.F	177.F	950.F	52.	-3.5	17.0	130.	6.	13.5	56.8	0.586	2.71	147	679	1606.
11/21/96 09:00:00 UNIT 182																
100	2174.	169.F	176.F	950.F	53.	-3.6	17.1	129.	6.	13.5	55.1	0.590	2.70	147	842	1607.

V.R.SYSTEMS INC. MODEL V3 S/N 182

PERMIT NO.

	ENGINE RPM	TEMPERATURE COOLANT	OIL	EXHAUST	OIL PSI	POSITIONS CARB.	BYPASS	WELL FLOW CFM	-VAC.H2O	BATTERY VOLTS	DUTY CYCLE	PERCENT OXYGEN	AUXILIARY FUEL CFM	THOUSANDS	-UNITS	ENGINE HOURS
11/21/96 10:00:00 UNIT 182																
100	2169.	169.F	176.F	951.F	52.	-3.8	17.1	129.	6.	13.5	56.3	0.587	2.71	148	6	1608.
11/21/96 10:48:59 UNIT 182																
100	2186.	169.F	177.F	949.F	52.	-3.8	17.0	130.	5.	13.6	57.4	0.585	2.69	148	140	1609.
11/21/96 10:57:49 UNIT 182																
100	2186.	168.F	176.F	967.F	53.	-3.8	17.0	130.	2.	13.5	58.0	0.584	2.68	148	164	1609.
11/21/96 11:00:00 UNIT 182																
100	2175.	169.F	175.F	972.F	53.	-4.3	17.0	130.	2.	13.4	57.3	0.585	2.66	148	170	1609.
11/21/96 11:03:54 UNIT 182																
100	1984.	167.F	172.F	961.F	53.	-5.1	13.4	113.	3.	13.5	60.0	0.580	2.57	148	180	1609.
11/21/96 11:04:05 UNIT 182																
100	1931.	167.F	172.F	952.F	53.	-4.9	12.4	109.	3.	13.3	57.7	0.585	2.48	148	181	1609.
11/21/96 11:04:29 UNIT 182																
100	1830.	167.F	171.F	932.F	53.	-5.0	10.0	101.	4.	13.5	60.3	0.579	2.28	148	182	1609.
11/21/96 11:04:50 UNIT 182																
100	1748.	167.F	171.F	915.F	53.	-4.9	8.8	95.	4.	13.5	58.7	0.583	2.13	148	182	1609.
11/21/96 11:06:40 UNIT 182																
100	1701.	165.F	168.F	862.F	53.	-1.5	8.7	84.	4.	13.5	56.2	0.588	1.93	148	186	1609.
11/21/96 11:08:04 UNIT 182																
100	1772.	165.F	167.F	854.F	53.	9.5	6.2	45.	5.	13.5	54.2	0.592	2.01	148	189	1610.
11/21/96 11:09:27 UNIT 182																
100	1864.	166.F	166.F	867.F	53.	14.0	2.9	32.	5.	13.5	56.4	0.587	2.13	148	192	1610.
11/21/96 11:13:33 UNIT 182																
100	1818.	167.F	166.F	856.F	53.	18.2	-0.3	0.	6.	13.6	48.8	0.602	0.00	148	198	1610.
11/21/96 11:14:03 UNIT 182																
100	1767.	166.F	166.F	846.F	53.	22.7	-0.3	0.	6.	13.5	9.8	0.680	0.00	148	198	1610.
11/21/96 11:15:00 UNIT 182																
100	1587.	166.F	165.F	870.F	53.	19.7	-0.3	0.	6.	13.5	9.8	0.680	0.00	148	198	1610.
11/21/96 11:15:21 UNIT 182																
100	1552.	166.F	166.F	849.F	53.	19.6	-0.3	0.	6.	13.6	9.8	0.680	0.00	148	198	1610.
11/21/96 11:24:39 UNIT 182																
100	1507.	164.F	161.F	739.F	53.	18.4	-0.4	0.	7.	13.6	9.8	0.680	0.00	148	199	1610.
11/21/96 11:25:01 UNIT 182																
100	1536.	164.F	162.F	738.F	53.	18.4	-0.4	0.	7.	13.5	9.8	0.680	0.00	148	199	1610.

11/21/96 11:37:33 LIMIT 414 ENG TMR OVRNG ENGINE FAILED ALARM UNIT 182

APPENDIX C

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: Illy AFB

Date: 11/11/96

Operator's Initials: _____

Equipment	Check if OK	Comments
Liquid Ring Pump	✓	
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flow Meter	✓	
Fuel Flow Meter	✓	
Water Flow Meter	✓	
Emergency Shut Off float Switch Effluent Transfer Tank	✓	
Analytical Field Instrumentation GasTechtor O_2/CO_2 Analyzer TraceTechtor Hydrocarbon Analyzer Oil/Water Interface Probe Magnehelic Boards Thermocouple Thermometer	 ✓ ✓ ✓ ✓ ✓	

APPENDIX D

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Baildown Test Record Sheet

Site: KELLY AFB

Well Identification: 008

Well Diameter (OD/ID): 4 in

Date at Start of Test: Nov 11, 96

Sampler's Initials: CC

Time at Start of Test: 1545

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L)
16.45	15.55	.90	2.825

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1545	15.83	15.76	.07
1545.5	15.83	15.74	.09
1546	15.83	15.74	.09
1546.5	15.84	15.74	.10
1547	15.84	15.74	.10
1548	15.85	15.74	.11
1549	15.85	15.74	.11
1550	15.85	15.75	.10
1555	15.88	15.74	.14
1615	15.92	15.73	.19
1655	15.97	15.73	.24
1726	15.97	15.73	.24
0751 (11/12)	16.37	15.62	.75

Figure 9. Typical Baildown Test Record Sheet

Baildown Test Record Sheet

Site: KELLY AFB

Well Identification: 009

Well Diameter (OD/ID): 4 in

Date at Start of Test: Nov 11, 96

Sampler's Initials: CC

Time at Start of Test: 1648

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L)
18.29	16.92	1.37	6.7

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1648	17.28	17.20	.08
1648.5	17.30	17.20	.10
1649	17.33	17.20	.13
1649.5	17.33	17.20	.13
1650	17.34	17.20	.14
1650.5	17.34	17.20	.14
1651	17.35	17.20	.15
1651.5	17.36	17.20	.16
1652	17.37	17.20	.17
1652.5	17.37	17.20	.17
1658	17.43	17.19	.24
1703	17.47	17.17	.30

Figure 9. Typical Baildown Test Record Sheet

Baildown Test Record Sheet

Site: KELLY AFB

Well Identification: O11

Well Diameter (OD/ID): 4 in

Date at Start of Test: Nov 11, 1996

Sampler's Initials: CC

Time at Start of Test: 15:04 hrs

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L)
16.59	15.21	1.38 Ft	~~1.95~~

7.38 L

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1504	15.57	15.53	.04
1504.5	15.61	15.53	.08
1505	15.64	15.52	.12
1505.5	15.65	15.51	.14
1506	15.68	15.50	.18
1506.5	15.69	15.49	.20
1507	15.72	15.48	.24
1507.5	15.73	15.46	.26
1508	15.75	15.47	.28
1509	15.78	15.47	.31
1510	15.79	15.47	.32
1511	15.80	15.47	.33

Figure 9. Typical Baildown Test Record Sheet

Baildown Test Record Sheet

Site: KELLY AFB

Well Identification: OII, cont'd

Well Diameter (OD/ID): ______

Date at Start of Test: ______ Sampler's Initials: ______

Time at Start of Test: ______

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L)

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1512	15.81	15.47	.34
1513	15.83	15.46	.37
1514	15.83	15.46	.37
1519	15.85	15.45	.40
1524	15.88	15.44	.44
1534	15.92	15.43	.49
1606	16.05	15.43	.62
1636	16.13	15.38	.75
1730	16.28	15.35	.93
1800	16.33	15.33	1.00
0753 (11/12)	16.63	15.25	1.38

Figure 9. Typical Baildown Test Record Sheet

Bioslurping Pilot Test
(Data Sheet 3B)
Fuel and Water Recovery Data

Site: Kelly AFB

Test Type: Initial Skimmer Well MW-11

Start Date and Time: 11/12/96 1430

Operators: Coonfare and Serpa

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
11/12/96 1530	1	sheen	130 gallons
11/12/96 1705	2.58	sheen	49.1
11/12/96 1820	3.83	sheen	90
11/12/96 2110	6.67	sheen	125
11/13/96 0730	17	sheen	210.6
11/13/96 1305	22.6	sheen	162.5
11/13/96 1640	26.2	sheen	297.2
11/13/96 1820	27.8	sheen	89.9
11/13/96 2215	31.8	sheen	448.5
11/14/96 0725	40.9	6.3	846.8
Total		6.3	2449.3

Bioslurping Pilot Test
(Data Sheet 3B)
Fuel and Water Recovery Data

Site: Kelly AFB

Test Type: Bioslurper Well MW-11

State Date and Time: 11/14/96 1119

Operators: Coonfare/Serpa

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
11/14/96 1147	0.47	System shutdown	
11/14/97 1338	0.47	Restart system	
11/14/96 1410	1	sheen	651.6
11/14/96 1600	2.83	6.1	458
11/14/96 2045	7.58	7.4	1187
11/15/96 0740	18.5	15.7	2629
11/15/96 1315	24.1	9.0	1284
11/15/96 2015	31.1	9.4	1610
11/16/96 0740	42.5	14.0	2637
11/16/96 1345	48.5	7.5	1347
11/16/96 1930	54.3	7.0	1276
11/17/96 0740	66.6	13.7	2738
11/17/96 1400	72.8	5.6	1395
11/17/96 2015	79.1	9.1	1404.4
11/18/96 0740	90.5	10.8	2428.6
11/18/96 1400	96.8	System shutdown	
11/18/96 1533	96.8	Restart system	
11/18/96 1625	97.7	8.6	1624
11/18/96 2025	101.7	6.3	864
11/19/96 0730	112.8	5.4	2277
11/19/96 1215	117.5	20.4	973
Total		156	26,783.6

Bioslurping Pilot Test
(Data Sheet 3B)
Fuel and Water Recovery Data

Site: Kelly AFB

Test Type: Bioslurper Well MW-09

State Date and Time: 11/19/96 1308

Operators: Coonfare/Serpa

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
11/19/96 1500	1.9	2.2	424
11/19/96 1950	6.7	10.0	1125
11/20/96 0745	18.6	23.0	2646
11/20/96 1300	23.9	13.4	1147
Total		48.6	5342

Bioslurping Pilot Test
(Data Sheet 3B)
Fuel and Water Recovery Data

Site: Kelly AFB

Test Type: Second Skimmer Well MW-11

State Date and Time: 11/20/96 1445

Operators: Coonfare/Serpa

Date/Time	Run Time	LNAPL Recovery (volume collected in time period)	Groundwater Recovery (volume collected in time period)
11/20/96 1930	4.7	4.2	651
11/20/96 1245	22.0	15.1	2401
Total		19.3	3052

Bioslurping Pilot Test
(Data Sheet 1)
Well Characteristics

Site: KELLY AFB

Test Type (skimmer, bioslurper vacuum extraction, drawdown): ____________

Depth to Groundwater: ________ Depth to Fuel: ________ Depth of Slurper Tube: ________

Date at Start of Test: ________

Time at Start of Test: ________ Operator's Initials: CC

Prior to testing

Date/Time	Well ID: 008 LNAPL Level	Well ID: 008 Water Level	Well ID: 008 Pressure (in H_2O)	Well ID: 009 LNAPL Level	Well ID: 009 Water Level	Well ID: 009 Pressure (in H_2O)	Well ID: 011 LNAPL Level	Well ID: 011 Water Level	Well ID: 011 Pressure (in H_2O)
11/11/96 1432	15.55	16.45		16.92	18.29		15.21	16.59	
11/12/96 0750	15.62	16.37		16.93	18.37		15.25	16.63	
11/14/96 1050	End of	skimmer	test on	Well 011			15.6	15.85	
11/17/96 1345	15.91	16.99		17.32	18.57	Slurping	on	Well 011	
11/19/96 1230	End Slurper	on Well	011	17.32	18.55		15.83	16.20	
11/20/96 1420	End slurper	on Well	009	17.51	17.80		15.75	16.75	

Figure 11. Typical Record Sheets for Bioslurper Pilot Testing

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page 1 of 1

Site: KELLY AFB

Operators: COONFARE / SERPA

Test Type: INITIAL SKIMMER

Depth to Groundwater: 16.63 Depth to Fuel: 15.25

Start Date: 11/12/96

Start Time: 1430

Well ID: 011

Depth of Tube: 15.6

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)	Drop Tube Vacuum (in. H_2O)
11/12/96 1530	1 hr	.045		24	48.2	22		45
11/12/96 1705	2 hr 35 min	.05		25	51.2	22		45
11/12/96 1820	3 hr 50 min	.05		25	51.6	22		45
CC 11/12/96 2110	6 hr 40 min	.045 ~~.05~~		24 ~~25~~	52.1 ~~51.6~~	21 ~~22~~		43 ~~45~~
11/13/96 0730	17 hr	.03		19	52.9	21		42
11/13/96 1305	22.7	.04		21	54.2	21		40
11/13/96 1640	26.3	.095		33	37.1	24		>60
11/13/96 1820	27.9	.09		32	38.2	24		50
11/13/96 2215	31.5	.08		31	38.5	24		55
11/14/96 0725	40.6	.07		29	39.4	23		52

Figure 11. Typical Record Sheets for Bioslurper Pilot Testing (Continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page 1 of 2

Site: KELLY AFB

Operators: COONFARE / SERPA

Test Type: BIOSLURPER

Depth to Groundwater: 15.85 Depth to Fuel: 15.6

Start Date: 11/14/96

Start Time: 1119

Well ID: O11

Depth of Tube: 15.7

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)	Drop Tube Vacuum (in. Hg)
11/14/96 1410	1 hr	.18		50	31.9	26	19	19
11/14/96 1600	3 hr	.18		50	33.6	25.5	20.5	19.5
11/14/96 2045	7.8	.165		44	27.3	25.5	21	19.5
11/15/96 0740	18.7	.19		51	27.9	25.5	21	19
11/15/96 1315	24.2	.20		51	30.7	25.5	21.5	19.5
11/15/96 2015	31.3	.185		50	28.5	25.5	22	19
11/16/96 0740	42.7	.185		50	28.5	25	22	19
11/16/96 1345	48.7	.205		52	33.4	25.5	22	19.5
11/16/96 1930	54.5	.195		51	29.3	25.5	22	19.5
11/17/96 0745	66.7	.20		51	29.5	25.5	22	19
11/17/96 1400	73	.20		51	30.3	25.5	22	19
11/17/96 2015	79.3	.195		51	26.9	25.5	22	19
11/18/96 0740	90.6	.19		51	27.5	25.5	22	19
11/18/96 1625	97.7	.20		51	29.3	25.5	22.5	19

Figure 11. Typical Record Sheets for Bioslurper Pilot Testing (Continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Site: KELLY AFB

Operators: COONFARE/SERPA

Test Type: BIOSLURPER, cont'd

Depth to Groundwater: 15.85 Depth to Fuel: 15.6

Start Date: 11/14/96

Start Time: 1119

Well ID: 011

Depth of Tube: 15.7

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)	Drop Tube Vacuum (in. Hg)
11/18/96 2025	101.7	.20		51	28.7	25.5	23	19
11/19/96 0730	112.9	.195		51	28.9	25.5	23	19

Figure 11. Typical Record Sheets for Bioslurper Pilot Testing (Continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page 1 of 1

Site: KELLY AFB

Operators: COINFARE/SERPA

Test Type: BIOSLURPER

Depth to Groundwater: 18.55 Depth to Fuel: 17.32

Start Date: 11/19/96

Start Time: 1308

Well ID: 009

Depth of Tube: 17.8

Date/Time	Run Time	Vapor Extraction			Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)	Drop Tube Vacuum (in. Hg)
		Stack Pressure (in. H_2O)	Carbon Drums (in. H_2O)	Flowrate (scfm)				
11/19/96 1500	1.9	.205		52	30.0	25.5	5	19
11/19/96 1950	6.7	.21		52	28.0	25.5	5	19
11/20/96 0745	18.6	.22		53	28.5	25.5	5	19
11/20/96 1245	23.6	.25		56	32.6	25.5	5	19

Figure 11. Typical Record Sheets for Bioslurper Pilot Testing (Continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page 1 of 1

Site: KELLY AFB

Operators: COONFARE / SERPA

Test Type: SECOND SKIMMER

Depth to Groundwater: 16.75 Depth to Fuel: 15.75

Start Date: 11/20/96

Start Time: 1445

Well ID: 011

Depth of Tube: 16.5

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)	Drop Tube Vacuum (in. Hg)
11/20/96 1930	4.7	.20		51	35.0	25.5		16.5
11/21/96 1245	22.1	.21		52	36.4	25.5		16.5

Figure 11. Typical Record Sheets for Bioslurper Pilot Testing (Continued)

APPENDIX E

LABORATORY ANALYTICAL REPORTS

AIR TOXICS LTD.

SAMPLE NAME: KLRPV-1

ID#: 9611209-01A

EPA METHOD TO-14 GC/MS Full Scan

File Name: 9113005 Date of Collection: 11/17/96
Dil. Factor: 808 Date of Analysis: 11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Freon 12	400	Not Detected
Freon 114	400	Not Detected
Chloromethane	400	Not Detected
Vinyl Chloride	400	Not Detected
Bromomethane	400	Not Detected
Chloroethane	400	Not Detected
Freon 11	400	Not Detected
1,1-Dichloroethene	400	Not Detected
Freon 113	400	Not Detected
Methylene Chloride	400	Not Detected
1,1-Dichloroethane	400	Not Detected
cis-1,2-Dichloroethene	400	2600
Chloroform	400	Not Detected
1,1,1-Trichloroethane	400	Not Detected
Carbon Tetrachloride	400	Not Detected
Benzene	400	Not Detected
1,2-Dichloroethane	400	Not Detected
Trichloroethene	400	3200
1,2-Dichloropropane	400	Not Detected
cis-1,3-Dichloropropene	400	Not Detected
Toluene	400	Not Detected
trans-1,3-Dichloropropene	400	Not Detected
1,1,2-Trichloroethane	400	Not Detected
Tetrachloroethene	400	Not Detected
Ethylene Dibromide	400	Not Detected
Chlorobenzene	400	Not Detected
Ethyl Benzene	400	Not Detected
m,p-Xylene	400	Not Detected
o-Xylene	400	Not Detected
Styrene	400	Not Detected
1,1,2,2-Tetrachloroethane	400	Not Detected
1,3,5-Trimethylbenzene	400	Not Detected
1,2,4-Trimethylbenzene	400	3000
1,3-Dichlorobenzene	400	Not Detected
1,4-Dichlorobenzene	400	Not Detected
Chlorotoluene	400	Not Detected
1,2-Dichlorobenzene	400	Not Detected
1,2,4-Trichlorobenzene	400	Not Detected
Hexachlorobutadiene	400	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: KLRPV-1

ID#: 9611209-01A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113006	Date of Collection:	11/17/96
Dil. Factor:	808	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Propylene	1600	Not Detected
1,3-Butadiene	1600	Not Detected
Acetone	1600	Not Detected
Carbon Disulfide	1600	Not Detected
2-Propanol	1600	Not Detected
trans-1,2-Dichloroethene	1600	Not Detected
Vinyl Acetate	1600	Not Detected
Chloroprene	1600	Not Detected
2-Butanone (Methyl Ethyl Ketone)	1600	Not Detected
Hexane	1600	Not Detected
Tetrahydrofuran	1600	Not Detected
Cyclohexane	1600	3200
1,4-Dioxane	1600	Not Detected
Bromodichloromethane	1600	Not Detected
4-Methyl-2-pentanone	1600	Not Detected
2-Hexanone	1600	Not Detected
Dibromochloromethane	1600	Not Detected
Bromoform	1600	Not Detected
4-Ethyltoluene	1600	Not Detected
Ethanol	1600	Not Detected
Methyl tert-Butyl Ether	1600	Not Detected
Heptane	1600	Not Detected
TPH*	4000	15000000

*Total Petroleum Hydrocarbons (C2 + Hydrocarbons) Referenced to Jet Fuel (MW = 156).

Q = Exceeds Quality Control limits.

Container Type: Tedlar Bag

Surrogates	% Recovery	Method Limits
Octafluorotoluene	109	70-130
Toluene-d8	103	70-130
4-Bromofluorobenzene	107 Q	70-130

AIR TOXICS LTD.

SAMPLE NAME: KICEV-1

ID#: 9611209-02A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113006	Date of Collection:	11/17/96
Dil. Factor:	142	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Freon 12	71	Not Detected
Freon 114	71	Not Detected
Chloromethane	71	Not Detected
Vinyl Chloride	71	Not Detected
Bromomethane	71	Not Detected
Chloroethane	71	Not Detected
Freon 11	71	Not Detected
1,1-Dichloroethene	71	Not Detected
Freon 113	71	Not Detected
Methylene Chloride	71	Not Detected
1,1-Dichloroethane	71	Not Detected
cis-1,2-Dichloroethene	71	Not Detected
Chloroform	71	Not Detected
1,1,1-Trichloroethane	71	Not Detected
Carbon Tetrachloride	71	Not Detected
Benzene	71	Not Detected
1,2-Dichloroethane	71	Not Detected
Trichloroethene	71	Not Detected
1,2-Dichloropropane	71	Not Detected
cis-1,3-Dichloropropene	71	Not Detected
Toluene	71	Not Detected
trans-1,3-Dichloropropene	71	Not Detected
1,1,2-Trichloroethane	71	Not Detected
Tetrachloroethene	71	Not Detected
Ethylene Dibromide	71	Not Detected
Chlorobenzene	71	Not Detected
Ethyl Benzene	71	Not Detected
m,p-Xylene	71	Not Detected
o-Xylene	71	Not Detected
Styrene	71	Not Detected
1,1,2,2-Tetrachloroethane	71	Not Detected
1,3,5-Trimethylbenzene	71	Not Detected
1,2,4-Trimethylbenzene	71	130
1,3-Dichlorobenzene	71	Not Detected
1,4-Dichlorobenzene	71	Not Detected
Chlorotoluene	71	Not Detected
1,2-Dichlorobenzene	71	Not Detected
1,2,4-Trichlorobenzene	71	Not Detected
Hexachlorobutadiene	71	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: KICEV-1

ID#: 9611209-02A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113006	Date of Collection:	11/12/96
Dil. Factor:	142	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Propylene	280	Not Detected
1,3-Butadiene	280	Not Detected
Acetone	280	Not Detected
Carbon Disulfide	280	Not Detected
2-Propanol	280	Not Detected
trans-1,2-Dichloroethene	280	Not Detected
Vinyl Acetate	280	Not Detected
Chloroprene	280	Not Detected
2-Butanone (Methyl Ethyl Ketone)	280	Not Detected
Hexane	280	Not Detected
Tetrahydrofuran	280	Not Detected
Cyclohexane	280	Not Detected
1,4-Dioxane	280	Not Detected
Bromodichloromethane	280	Not Detected
4-Methyl-2-pentanone	280	Not Detected
2-Hexanone	280	Not Detected
Dibromochloromethane	280	Not Detected
Bromoform	280	Not Detected
4-Ethyltoluene	280	Not Detected
Ethanol	280	Not Detected
Methyl tert-Butyl Ether	280	Not Detected
Heptane	280	Not Detected
TPH*	710	760000

*Total Petroleum Hydrocarbons (C2 + Hydrocarbons) Referenced to Jet Fuel (MW = 156).

Container Type: Tedlar Bag

Surrogates	% Recovery	Method Limits
Octafluorotoluene	110	70-130
Toluene-d8	105	70-130
4-Bromofluorobenzene	120	70-130

AIR TOXICS LTD.

SAMPLE NAME: KLRPV-2

ID#: 9611209-03A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113007	Date of Collection:	11/18/96
Dil. Factor:	1420	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Freon 12	710	Not Detected
Freon 114	710	Not Detected
Chloromethane	710	Not Detected
Vinyl Chloride	710	Not Detected
Bromomethane	710	Not Detected
Chloroethane	710	Not Detected
Freon 11	710	Not Detected
1,1-Dichloroethene	710	Not Detected
Freon 113	710	Not Detected
Methylene Chloride	710	Not Detected
1,1-Dichloroethane	710	Not Detected
cis-1,2-Dichloroethene	710	2900
Chloroform	710	Not Detected
1,1,1-Trichloroethane	710	Not Detected
Carbon Tetrachloride	710	Not Detected
Benzene	710	Not Detected
1,2-Dichloroethane	710	Not Detected
Trichloroethene	710	2700
1,2-Dichloropropane	710	Not Detected
cis-1,3-Dichloropropene	710	Not Detected
Toluene	710	Not Detected
trans-1,3-Dichloropropene	710	Not Detected
1,1,2-Trichloroethane	710	Not Detected
Tetrachloroethene	710	Not Detected
Ethylene Dibromide	710	Not Detected
Chlorobenzene	710	Not Detected
Ethyl Benzene	710	Not Detected
m,p-Xylene	710	Not Detected
o-Xylene	710	Not Detected
Styrene	710	Not Detected
1,1,2,2-Tetrachloroethane	710	Not Detected
1,3,5-Trimethylbenzene	710	Not Detected
1,2,4-Trimethylbenzene	710	5400
1,3-Dichlorobenzene	710	Not Detected
1,4-Dichlorobenzene	710	Not Detected
Chlorotoluene	710	Not Detected
1,2-Dichlorobenzene	710	Not Detected
1,2,4-Trichlorobenzene	710	Not Detected
Hexachlorobutadiene	710	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: KLRPV-2

ID#: 9611209-03A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113007	Date of Collection:	11/18/96
Dil. Factor:	1420	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Propylene	2800	Not Detected
1,3-Butadiene	2800	Not Detected
Acetone	2800	Not Detected
Carbon Disulfide	2800	Not Detected
2-Propanol	2800	Not Detected
trans-1,2-Dichloroethene	2800	Not Detected
Vinyl Acetate	2800	Not Detected
Chloroprene	2800	Not Detected
2-Butanone (Methyl Ethyl Ketone)	2800	Not Detected
Hexane	2800	Not Detected
Tetrahydrofuran	2800	Not Detected
Cyclohexane	2800	3900
1,4-Dioxane	2800	Not Detected
Bromodichloromethane	2800	Not Detected
4-Methyl-2-pentanone	2800	Not Detected
2-Hexanone	2800	Not Detected
Dibromochloromethane	2800	Not Detected
Bromoform	2800	Not Detected
4-Ethyltoluene	2800	Not Detected
Ethanol	2800	Not Detected
Methyl tert-Butyl Ether	2800	Not Detected
Heptane	2800	2900
TPH*	7100	29000000

*Total Petroleum Hydrocarbons (C2 + Hydrocarbons) Referenced to Jet Fuel (MW = 156).

Q = Exceeds Quality Control limits.

Container Type: Tedlar Bag

Surrogates	% Recovery	Method Limits
Octafluorotoluene	106	70-130
Toluene-d8	103	70-130
4-Bromofluorobenzene	153 Q	70-130

AIR TOXICS LTD.

SAMPLE NAME: KICEV-2

ID#: 9611209-04A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9118008	Date of Collection:	11/18/96
Dil. Factor:	183	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Freon 12	92	Not Detected
Freon 114	92	Not Detected
Chloromethane	92	Not Detected
Vinyl Chloride	92	Not Detected
Bromomethane	92	Not Detected
Chloroethane	92	Not Detected
Freon 11	92	Not Detected
1,1-Dichloroethene	92	Not Detected
Freon 113	92	Not Detected
Methylene Chloride	92	Not Detected
1,1-Dichloroethane	92	Not Detected
cis-1,2-Dichloroethene	92	Not Detected
Chloroform	92	Not Detected
1,1,1-Trichloroethane	92	Not Detected
Carbon Tetrachloride	92	Not Detected
Benzene	92	Not Detected
1,2-Dichloroethane	92	Not Detected
Trichloroethene	92	Not Detected
1,2-Dichloropropane	92	Not Detected
cis-1,3-Dichloropropene	92	Not Detected
Toluene	92	Not Detected
trans-1,3-Dichloropropene	92	Not Detected
1,1,2-Trichloroethane	92	Not Detected
Tetrachloroethene	92	Not Detected
Ethylene Dibromide	92	Not Detected
Chlorobenzene	92	Not Detected
Ethyl Benzene	92	Not Detected
m,p-Xylene	92	Not Detected
o-Xylene	92	Not Detected
Styrene	92	Not Detected
1,1,2,2-Tetrachloroethane	92	Not Detected
1,3,5-Trimethylbenzene	92	Not Detected
1,2,4-Trimethylbenzene	92	340
1,3-Dichlorobenzene	92	Not Detected
1,4-Dichlorobenzene	92	Not Detected
Chlorotoluene	92	Not Detected
1,2-Dichlorobenzene	92	Not Detected
1,2,4-Trichlorobenzene	92	Not Detected
Hexachlorobutadiene	92	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: KICEV-2

ID#: 9611209-04A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113008	Date of Collection: 11/18/96
Dil. Factor:	183	Date of Analysis: 11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Propylene	370	Not Detected
1,3-Butadiene	370	Not Detected
Acetone	370	Not Detected
Carbon Disulfide	370	Not Detected
2-Propanol	370	Not Detected
trans-1,2-Dichloroethene	370	Not Detected
Vinyl Acetate	370	Not Detected
Chloroprene	370	Not Detected
2-Butanone (Methyl Ethyl Ketone)	370	Not Detected
Hexane	370	Not Detected
Tetrahydrofuran	370	Not Detected
Cyclohexane	370	Not Detected
1,4-Dioxane	370	Not Detected
Bromodichloromethane	370	Not Detected
4-Methyl-2-pentanone	370	Not Detected
2-Hexanone	370	Not Detected
Dibromochloromethane	370	Not Detected
Bromoform	370	Not Detected
4-Ethyltoluene	370	Not Detected
Ethanol	370	Not Detected
Methyl tert-Butyl Ether	370	Not Detected
Heptane	370	Not Detected
TPH*	920	1600000

*Total Petroleum Hydrocarbons (C2 + Hydrocarbons) Referenced to Jet Fuel (MW = 156).

Container Type: Tedlar Bag

Surrogates	% Recovery	Method Limits
Octafluorotoluene	111	70-130
Toluene-d8	103	70-130
4-Bromofluorobenzene	129	70-130

AIR TOXICS LTD.

SAMPLE NAME: KICE-SP-1

ID#: 9611209-05A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113009	Date of Collection: 11/18/96
Dil. Factor:	174	Date of Analysis: 11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Freon 12	87	Not Detected
Freon 114	87	Not Detected
Chloromethane	87	Not Detected
Vinyl Chloride	87	Not Detected
Bromomethane	87	Not Detected
Chloroethane	87	Not Detected
Freon 11	87	Not Detected
1,1-Dichloroethene	87	Not Detected
Freon 113	87	Not Detected
Methylene Chloride	87	Not Detected
1,1-Dichloroethane	87	Not Detected
cis-1,2-Dichloroethene	87	Not Detected
Chloroform	87	Not Detected
1,1,1-Trichloroethane	87	Not Detected
Carbon Tetrachloride	87	Not Detected
Benzene	87	Not Detected
1,2-Dichloroethane	87	Not Detected
Trichloroethene	87	Not Detected
1,2-Dichloropropane	87	Not Detected
cis-1,3-Dichloropropene	87	Not Detected
Toluene	87	Not Detected
trans-1,3-Dichloropropene	87	Not Detected
1,1,2-Trichloroethane	87	Not Detected
Tetrachloroethene	87	Not Detected
Ethylene Dibromide	87	Not Detected
Chlorobenzene	87	Not Detected
Ethyl Benzene	87	Not Detected
m,p-Xylene	87	100
o-Xylene	87	Not Detected
Styrene	87	Not Detected
1,1,2,2-Tetrachloroethane	87	Not Detected
1,3,5-Trimethylbenzene	87	Not Detected
1,2,4-Trimethylbenzene	87	350
1,3-Dichlorobenzene	87	Not Detected
1,4-Dichlorobenzene	87	Not Detected
Chlorotoluene	87	Not Detected
1,2-Dichlorobenzene	87	Not Detected
1,2,4-Trichlorobenzene	87	Not Detected
Hexachlorobutadiene	87	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: KICE-SP-1

ID#: 9611209-05A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113009	Date of Collection:	11/18/96
Dil. Factor:	174	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Propylene	350	Not Detected
1,3-Butadiene	350	Not Detected
Acetone	350	Not Detected
Carbon Disulfide	350	Not Detected
2-Propanol	350	Not Detected
trans-1,2-Dichloroethene	350	Not Detected
Vinyl Acetate	350	Not Detected
Chloroprene	350	Not Detected
2-Butanone (Methyl Ethyl Ketone)	350	Not Detected
Hexane	350	Not Detected
Tetrahydrofuran	350	Not Detected
Cyclohexane	350	Not Detected
1,4-Dioxane	350	Not Detected
Bromodichloromethane	350	Not Detected
4-Methyl-2-pentanone	350	Not Detected
2-Hexanone	350	Not Detected
Dibromochloromethane	350	Not Detected
Bromoform	350	Not Detected
4-Ethyltoluene	350	Not Detected
Ethanol	350	Not Detected
Methyl tert-Butyl Ether	350	Not Detected
Heptane	350	Not Detected
TPH*	870	770000

*Total Petroleum Hydrocarbons (C2 + Hydrocarbons) Referenced to Jet Fuel (MW = 156).

Container Type: Tedlar Bag

Surrogates	% Recovery	Method Limits
Octafluorotoluene	106	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	115	70-130

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9611209-06A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113004	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Freon 12	0.50	Not Detected
Freon 114	0.50	Not Detected
Chloromethane	0.50	Not Detected
Vinyl Chloride	0.50	Not Detected
Bromomethane	0.50	Not Detected
Chloroethane	0.50	Not Detected
Freon 11	0.50	Not Detected
1,1-Dichloroethene	0.50	Not Detected
Freon 113	0.50	Not Detected
Methylene Chloride	0.50	Not Detected
1,1-Dichloroethane	0.50	Not Detected
cis-1,2-Dichloroethene	0.50	Not Detected
Chloroform	0.50	Not Detected
1,1,1-Trichloroethane	0.50	Not Detected
Carbon Tetrachloride	0.50	Not Detected
Benzene	0.50	Not Detected
1,2-Dichloroethane	0.50	Not Detected
Trichloroethene	0.50	Not Detected
1,2-Dichloropropane	0.50	Not Detected
cis-1,3-Dichloropropene	0.50	Not Detected
Toluene	0.50	Not Detected
trans-1,3-Dichloropropene	0.50	Not Detected
1,1,2-Trichloroethane	0.50	Not Detected
Tetrachloroethene	0.50	Not Detected
Ethylene Dibromide	0.50	Not Detected
Chlorobenzene	0.50	Not Detected
Ethyl Benzene	0.50	Not Detected
m,p-Xylene	0.50	Not Detected
o-Xylene	0.50	Not Detected
Styrene	0.50	Not Detected
1,1,2,2-Tetrachloroethane	0.50	Not Detected
1,3,5-Trimethylbenzene	0.50	Not Detected
1,2,4-Trimethylbenzene	0.50	Not Detected
1,3-Dichlorobenzene	0.50	Not Detected
1,4-Dichlorobenzene	0.50	Not Detected
Chlorotoluene	0.50	Not Detected
1,2-Dichlorobenzene	0.50	Not Detected
1,2,4-Trichlorobenzene	0.50	Not Detected
Hexachlorobutadiene	0.50	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9611209-06A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	9113004	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 11/30/96

Compound	Det. Limit (ppbv)	Amount (ppbv)
Propylene	2.0	Not Detected
1,3-Butadiene	2.0	Not Detected
Acetone	2.0	Not Detected
Carbon Disulfide	2.0	Not Detected
2-Propanol	2.0	Not Detected
trans-1,2-Dichloroethene	2.0	Not Detected
Vinyl Acetate	2.0	Not Detected
Chloroprene	2.0	Not Detected
2-Butanone (Methyl Ethyl Ketone)	2.0	Not Detected
Hexane	2.0	Not Detected
Tetrahydrofuran	2.0	Not Detected
Cyclohexane	2.0	Not Detected
1,4-Dioxane	2.0	Not Detected
Bromodichloromethane	2.0	Not Detected
4-Methyl-2-pentanone	2.0	Not Detected
2-Hexanone	2.0	Not Detected
Dibromochloromethane	2.0	Not Detected
Bromoform	2.0	Not Detected
4-Ethyltoluene	2.0	Not Detected
Ethanol	2.0	Not Detected
Methyl tert-Butyl Ether	2.0	Not Detected
Heptane	2.0	Not Detected
TPH*	5.0	Not Detected

*Total Petroleum Hydrocarbons (C2 + Hydrocarbons) Referenced to Jet Fuel (MW = 156).

Container Type: NA

Surrogates	% Recovery	Method Limits
Octafluorotoluene	108	70-130
Toluene-d8	101	70-130
4-Bromofluorobenzene	104	70-130

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#:
Phone: (614) 424-6199
Attn: Chris Coonfare

Sampled: 11/17/96 Received: 11/20/96 Analyzed: 11/26/96

Matrix: [ ] Soil [ ] Water [X] Other

Analysis Requested: BTEX - Benzene,Toluene,Xylenes,Ethylbenzene

Methodology: BTEX - EPA Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration mg/Kg	Detection Limit mg/Kg
K-LNAPL-1	Benzene	ND	500
/BMI112096-01	Toluene	ND	500
	Ethylbenzene	ND	500
	Total Xylenes	ND	500

ND - Not Detected

Approved by: Roger L. Scholl Date: 12/2/96
Roger L. Scholl, Ph.D.
Laboratory Director

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#:
Phone: (614) 424-6199
Attn: Chris Coonfare

Sampled: 11/17/96 Received: 11/20/96 Analyzed: 11/26/96

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene, Toluene, Ethylbenzene, Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
K-W-1	TPH (Purgeable)	3.5	1.0	mg/L
/BMI112096-02	Benzene	ND	2.0	ug/L
	Toluene	ND	2.0	ug/L
	Ethylbenzene	ND	2.0	ug/L
	Total Xylenes	ND	2.0	ug/L

ND - Not Detected

Approved by: Roger L. Scholl Date: 12/2/96
Roger L. Scholl, Ph.D.
Laboratory Director

Billing Information:

Name

Address

City, State, Zip

Phone Number Fax

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 1

Client Name Intellec	P.O. #	Job #
Address	PWS #	DWR #
City, State, Zip	Phone #	Fax #

Sampled by

Report Attention Chris Goodman

Analyses Required

Time Sampled	Date Sampled	Matrix* See Key Below	Office Use Only Lab ID Number	Sample Description	Total and type of containers ** See below	BTXE	TPH/Extract										
	11/17	OT	BmI112096-01	K-LNAPL-1	1-O	X											
	11/17	AQ	02	K-W-1	3V	X	X										

REMARKS:

01- Tin Can product

Signature		Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Byrdick	Linda Byrdick	AAI	11/20/96	1030
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

[redacted] Key: AQ-Aqueous [redacted] SO-Soil [redacted] WA-Waste OT-Other [redacted] [redacted] **: L-Liter V-Voa S-Soil Jar [redacted] O-Orbo [redacted] T-Tedlar B-Brass P-Plastic [redacted] OT-Other [redacted]

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No.

Proj. No. G46Z201-30C0901

Project Title Kelly AFB Bioslurper Pilot Test

SAMPLERS: (Signature)

DATE	TIME	SAMPLE I.D.	BTEX 8020	BTEX	TPH / jet fuel	Container No.	Number of Containers	Remarks
11/17/96	1300 hrs	K-LNAPL-1	✓			1	1	Free product
11/17/96	1545 hrs	K-W-1		X	X	1-3	3	water

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
	11/17/96 1600				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
			11/20/96 1050	

e 1 of 1

WORK ORDER #: 9611209

Work Order Summary

CLIENT: Ms. Amanda Bush
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201-2693

BILL TO: Same

PHONE: 614-424-4996
FAX: 614-424-3667
DATE RECEIVED: 11/20/96
DATE COMPLETED:

INVOICE #
P.O. # 91221
PROJECT # G462201-30C0901 Kelly AFB

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	KLRPV-1	TO-14	0 "Hg
02A	KICEV-1	TO-14	1.5 "Hg
03A	KLRPV-2	TO-14	1.5 "Hg
04A	KICEV-2	TO-14	2.5 "Hg
05A	KICE-SP-1	TO-14	1.0 "Hg
06A	Lab Blank	TO-14	NA

PRELIMINARY

LAB NARRATIVE:
All samples were diluted due to high levels of non target compounds.

CERTIFIED BY: Debbie Pearce for
Laboratory Director

DATE: 12-5-96

APPENDIX F

SOIL GAS PERMEABILITY TEST RESULTS

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: Nov 14, 96 / 1119
DISTANCE FROM VENT WELL (ft. & tenths)	10.0	10.0	10.0		SITE: KELLY AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: COONFARE/SERPA
	MPA Green 5.5 ft	MPA Blue 9.0 ft	MPA Red 12.5 ft		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
0	.05	.05	.05		
1	.05	.04	.03		
3	.06	.05	.05		
5	.05	.05	.05		
7	.05	.05	.04		
9	.065	.06	.055		
11	.05	.03	.035		
13	.04	.035	.02		
15	.055	.025	.02		
17	.05	.025	.03		
27	.20	.08	.05		Shut down bioslurper
139	—	—	—		~~Shut~~ Restart bioslurper
141	.50	.25	.12		
143	.055	.03	.02		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME:
DISTANCE FROM VENT WELL (ft. & tenths)	10.0	10.0	10.0		SITE: Kelly AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY:
	MPA Green 5.5 ft	MPA Blue 9.0 ft	MPA Red 12.5 ft		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
1286	.04	.04	.035		
2701	.095	.11	.125		
4341	.105	.14	.14		
5746	+	+	+		
6986	.13	.14	.16		
1215 hrs 11/14/96	—	—	—		Shutdown slurper on well 011
1308 hrs 11/19/96	—	—	—		Start slurper on Well 009
8441	0	0	0		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: Nov 14, 96 / 1119
DISTANCE FROM VENT WELL (ft. & tenths)	23.0	23.0	23.0		SITE: KELLY AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: COONFARE / SERPA
	MPB Green 6.0 ft	MPB Blue 10.0 ft	MPB Red 13.5 ft		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
0	0	0	0		
1	.025	.02	.02		
3	.025	.01	.03		
5	0	.01	.02		
7	.005	.03	.03		
9	0	0	.015		
11	0	0	0		
13	0	.01	.015		
15	0	.01	.02		
17	0	.01	.03		
27	.01	.02	.03		Shut down bioslurper
139	~~0~~	~~0~~	~~0~~		Restart bioslurper
141	0 ~~.005~~	0	0		
143	.005	0	0		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME:
DISTANCE FROM VENT WELL (ft. & tenths)	23.0	23.0	23.0		SITE: Kelly AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY:
	MPB Green 6.0 ft	MPB Blue 10.0 ft	MPB Red 13.5 ft		
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	COMMENTS
1286	1.10	.50	.255		
2701	>50	5.0	2.0		
4341	>50	1.1	1.0		
5746	>50	5.0	1.25		
6986	>50	3.5	1.5		
1215 hrs (11/19/96)	—	—	—		Shutdown bioslurper on Well 011
1308 hrs (11/19/96)	—	—	—		Start bioslurper on Well 009
8441	20	0	0		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: Nov 14, 96 / 1119
DISTANCE FROM VENT WELL (ft. & tenths)	30.0	30.0	30.0		SITE: KELLY AFB
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: COONFARE/SERPA
	MPC Green 6.0 ft	MPC Blue 10.0 ft	MPC Red 14.0 ft		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
0	0	0	0		
1	0	0	.01		
3	0	0	.01		
5	.01	.01	.01		
7	.01	.01	.01		
9	.005	.005	.005		
11	0	0	.005		
13	.015	.01	.01		
15	.05	.01	.01		
17	.01	.01	.015		
27	.01	.01	.01		Shut down bioslurper
139	—	—	—		Restart bioslurper
141	0	0	0		
143	0	0	.005		

APPENDIX G

IN SITU RESPIRATION TEST RESULTS

Record Sheet for In Situ Respiration Test

Site KELLY AFB	**Monitoring Point** MPA Red 12.5 ft	
Shutdown Date 11/21/96	**O_2/CO_2 Meter No.**	**TPH Meter No.**
Shutdown Time 1500 hrs	**Recorded by** COONFARE/SERPA	

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
11/21/96	1500	21	0	60	0		
11/21/96	1530	21	0	160	0		
11/21/96	1700	21	0.25	340	—		
11/21/96	1830	18.5	0.2	580	—		
11/21/96	2030	17.0	0.25	720	—		
11/21/96	2230	14.5	0.25	1100	—		
11/22/96	0030	13.5	0.25	1080	—		
11/22/96	0330	11.5	0	1300	—		
11/22/96	0730	11.0	0.5	1600	—		
11/22/96	1000	9.5	0.25	860	—		TPH w/ 1:1 diluter
11/22/96	1300	7.5	0.5	1220	—		TPH w/ 1:1 diluter
11/22/96	1530	7.0	0.5	1200	—		TPH w/ 1:1 diluter
11/22/96	1700	5.5	0.5	1600	—		TPH w/ 1:1 diluter

Record Sheet for In Situ Respiration Test

Site KELLY AFB	Monitoring Point MPB Red 13.5 ft		
Shutdown Date 11/21/96	O_2/CO_2 Meter No.	TPH Meter No.	
Shutdown Time 1500 hrs	Recorded by COONFARE / SERPA		

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
11/21/96	1500	21	0	180	0		
11/21/96	1530	21	0	180	0		
11/21/96	1700	20.0	0	580	—		
11/21/96	1830	17.5	0.25	860	—		
11/21/96	2030	13.0	0.1	1400	—		
11/21/96	2230	12.0	0.25	1440	—		
11/22/96	0030	10.5	0.25	1440	—		
11/22/96	0330	9.0	0	140	—		TPH w/ 1:1 diluter
11/22/96	0730	4.0	0.25	1800	—		TPH w/ 1:1 diluter
11/22/96	1000	3.0	0.25	1620	—		TPH w/ 1:1 diluter
11/22/96	1300	2.0	0.25	1800	—		TPH w/ 1:1 diluter
11/22/96	1530	2.0	0.25	2000	—		TPH w/ 1:1 diluter
11/22/96	1700	1.5	0.25	1940	—		TPH w/ 1:1 diluter

Record Sheet for In Situ Respiration Test

Site KELLY AFB	Monitoring Point MPC Red 14.0 ft
Shutdown Date 11/21/96	O_2/CO_2 Meter No. / TPH Meter No.
Shutdown Time 1500 hrs	Recorded by COONFARE/SERPA

Date	Time	O_2 (%)	CO_2 (%)	TPH (ppm)	He (%)	Temperature (°C)	Comments
11/21/96	1500	21	0	840	0		
11/21/96	1530	21	0	200	0		
11/21/96	1700	20.5	0.25	500	—		
11/21/96	1830	18.0	0.25	700	—		
11/21/96	2030	15.5	0.25	1180	—		
11/21/96	2230	12.5	0.25	1540	—		
11/22/96	0030	11.0	0.25	1400	—		
11/22/96	0330	10.5	0.25	1600	—		
11/22/96	0730	8.5	0.25	1280	—		TPH w/ 1:1 diluter
11/22/96	1000	5.5	0.25	1240	—		TPH w/ 1:1 diluter
11/22/96	1300	7.0	0.5	1660	—		TPH w/ 1:1 diluter
11/22/96	1530	5.0	0.5	1440	—		TPH w/ 1:1 diluter
11/22/96	1700	5.5	0.25	1400	—		TPH w/ 1:1 diluter